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Appendix M:

4Sight Maintenance Dredging and Disposal

Ecology and Water Quality Report

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LAND. PEOPLE. WATER.

Eastland Port

GISBORNE PORT: MAINTENANCE DREDGING & ASSOCIATED DISPOSAL OF DREDGED MATERIAL
Port Navigation Channel, Vessel Turning Basin and Wharves 4-8

For Eastland Port

Resource Consent Application
Assessment of Environmental Effects
Ecology and Water Quality Report

February 2020

REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

This Ecology and Water Quality Report (EWQR) has been prepared for Eastland Port Ltd (Eastland hereafter) in support of resource consent applications to Gisborne District Council (GDC hereafter) to undertake maintenance dredging for the areas adjacent to Wharves 4, 5, 6, 7 and 8, the Vessel Turning Basin (VTB hereafter) and Port Navigation Channel (PNC hereafter) within the Port of Gisborne, and to dispose of the dredged material at the existing offshore disposal ground (ODG) being an area approximately 4 km offshore which is subject to the Port Management zone in the Tairawhiti Plan[1]. The report assesses the ecological and water quality effects of the dredging and disposal.

The scope of the EWQR covers the proposed maintenance dredging and disposal activities, which seek to replace the existing consents for the same activity which expire in August 2020. An aerial photograph of the port is presented as Figure 1 below.

Figure 1: Gisborne Port

1.1 Report Contents

This EWQR contains the following:

- A general description of the site and the proposal (Section 2);
- Existing ecology, water quality and sediment quality at the port, adjacent areas and the ODG (Section 3);
- An ecological and water quality effects assessment (EWQA) of the proposal (Section 4);

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[1] The ODG is referred to in the Tairāwhiti Plan as the Spoil Dump Outer zone and by reference to the four corner points having the following NZMG co-ordinators (Northings Eastings): 6264555 2942481, 6265899 2943969, 6263518 2944289, and 6264035 2944822.

- Proposed monitoring (Section 5);
- Consent Term (Section 6); and
- Conclusions of the report findings (Section 7).

1.2 Supporting Plans and Reports

This EWQR is supported by and relies on comprehensive plans and reports from the following consultants (References are cited in the text of the EWQR as applicable):

- Engineering – Worley Parsons
- Geological Model – Tonkin and Taylor
- Geophysical Survey – Marine and Earth Sciences
- Coastal Processes – MetOcean Solutions: A suite of physical modelling reports which collectively assess the dredging and disposal in terms of morphological responses and plume generation (and which are listed in section 2.8 of the 4Sight Assessment of Environmental Effects[2] (AEE)).

2 PORT MAINTENANCE DREDGING AND DISPOSAL

The Gisborne Port site and history is detailed in section 2.1 and 2.2 of the 4Sight AEE and is not repeated here.

The extent of maintenance dredging and the disposal area covered by the application is shown in Figure 2.

Maintenance dredging is presently routinely carried out in the port are pursuant to existing consents which expire in August 2020. Pursuant to those consents Eastland removes a variable volume of dredged sediment annually. The application seeks consent for dredging up to 140,000 m^3 annually (as currently consented). More typically the annual volume that is dredged and removed is less than 100,000 m^3 (section 2.9, 4Sight AEE). The application seeks consent for disposal of the same volume of dredged material from these operations to the ODG. The application also seeks consent for the associated decant and other discharges to seawater from the dredging and disposal operations.

The application specifically retains flexibility in respect of the nature of maintenance dredging methods to be employed. However it is likely Eastland will continue its current practice, using the Eastland's Trailing Suction Hopper Dredge (TSHD) 'Pukunui' (capacity 480 m^3: 220 m^3 solids and 260 m^3 water), or in more confined areas of the inner harbour and close to structures, a 'spud' barge mounted backhoe delivering to a hopper. Both these vessels would then be towed by a small tug to the ODG. Larger self-propelled trailer suction dredges, such as the 'Kawateri' or 'Albatros', could also be used depending on availability, or following storm events and larger than expected sediment inputs. The proposed methods are either the same, or will be similar, to those currently used.

Seabed material, if it has been dredged by a TSHD will be conveyed to the ODG as a slurry in a hopper barge (as in the case of the Pukunui). The composition of the slurry is expected to be about 80% solids, 20% water.

A backhoe operation may also fill a hopper barge which will also be towed to the ODG. The composition of a barge filled by this method is likely to contain less water.

At the ODG, the moving barge opens the hopper and the dredged material is released. This method optimises dispersal of the material within the ODG.

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[2] 4Sight Consulting (date December 2019). *Gisborne Port Maintenance Dredging and Disposal Wharves 4, 5, 6, 7 and 8, Vessel Turning Basin and Port Navigation Channel Resource Consent Applications Assessment of Environmental Effects*. Prepared for Eastland Port

3 EXISTING ECOLOGY, WATER AND SEDIMENT QUALITY

This section of the report addresses the following matters:

Existing environment generally

Port

- Ecology of the port seabed, port areas and adjacent zones potentially affected by dredging;
- Water quality of the port; and
- Physical and chemical characterisation of sediments to be dredged by maintenance dredging.

Offshore Disposal Ground

- Ecology of the ODG;
- Water Quality of the ODG; and
- Sediments of the ODG.

3.1 Existing Environment

The existing environment for the purpose of these applications is the actual background environment of the port, adjacent areas and ODG, excluding the effects of the current maintenance and disposal consent applications that are sought to be replaced by the current applications.

To exclude the effects of the existing maintenance dredging consents, we have assessed the actual background environment in and around the port site and applied our expert view as to whether the current maintenance dredging activities are likely to be having any impact.

As noted below, even excluding the existing maintenance dredging activity, the existing environment of the port area is already impacted by high levels and variability of natural sediment as well as high turbidity and sediment entrainment as a result of movement of vessels within the inner harbour.

3.2 Ecology of the Port

The following sections review information available on the ecology of the port. Figure 1 above sets out the main areas of the port and adjacent coastal areas relevant to the assessment of the existing ecology of the port area and its surrounds.

Figure 2: Maintenance dredged footprint within the port and Offshore Disposal Ground

3.2.1 NIWA 2005 Port Study

The marine biota has been documented as part of a 2005 baseline biosecurity study which sampled locations throughout the Gisborne Port (turning basin, berth pockets, wharfs, training wall and Butlers wall) (NIWA (2005)[3]). The report was stated as intended that '*the surveys* [which included most other ports around New Zealand] *will form a baseline for future monitoring of new incursions by non-indigenous marine species in port environments nationwide…*'.

The NIWA report provided a baseline inventory of native, non-indigenous and cryptogenic marine species within the port. Sampling targeted all habitats within the port and included mobile predators and scavengers which were sampled using baited fish, crab, starfish and shrimp traps.

The NIWA survey recorded 205 species or higher taxa from within the port. Biota comprised 130 native species, 14 non-indigenous species, 17 cryptogenic species (those whose geographic origins are uncertain) and 44 species indeterminata (taxa for which there is insufficient taxonomic or systematic information available to allow identification to species level).

As part of the 2005 study, NIWA divers made visual searches of breakwaters and rock facings within the commercial port area. Benthic scavengers and fish were sampled using a variety of baited traps, and eight sites around the port wharves, turning basin and training wall were sampled.

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[3] Inglis, G., Gust, N., Fitridge, I., Floerl, O., Woods, C., Hayden, B. and Fenwick, G (2005). *Port of Gisborne Baseline survey for non-indigenous marine species* (Research Project ZBS2000/04). Prepared by NIWA for Biosecurity New Zealand, Technical Paper No: 2005/11

Native species represented approximately 63% of all species identified from the port and included diverse assemblages of annelids (34 species), crustaceans (22 species), molluscs (20 species), phycophyta (16 species) and vertebrata (11 species). Other less diverse phyla including bryozoans, cnidarians, echinoderms, porifera, pyrrophycophyta and urochordates were also sampled from the port. Results recorded one juvenile *Jasus edwardsii* (crayfish) from the fish traps, two from the starfish traps and none were recorded from the shrimp traps.

Only presence/absence of taxa were recorded in the biosecurity data, not abundance. A limited range in macroinvertebrate biota were returned in the sampling of the seabed using grabs, sleds and traps. Most of the diversity was recorded from diver observations and scrapings from piles and hard surfaces.

In terms of species diversity, the 2005 NIWA study placed the Gisborne port in a ranking of 10th highest out of the 16 port and marina sites surveyed throughout New Zealand. The percentage composition of native species at the port was similar to nine of the other locations.

The 2005 NIWA study suggests that at that time the port environment (including its water quality) sustained a relatively diverse assemblage of marine life (that is compared to other ports) predominantly associated with the port structures. This is as would be expected given that the soft substrata of the port environment adjacent to the port structures, offer a much more limited opportunity as habitat for marine life. It is noted that the port structures are not directly affected by these applications and additional mitigation is proposed to limit dredging related water quality effects on hard surface biota and habitat (i.e. backhoe dredging in the Wharf6 & 7 the berth pockets to reduce sediment plume effects near a juvenile crayfish settlement area).

3.2.2 Biosecurity Surveillance 2004 – 2020

Currently, annual SCUBA based biosecurity surveys are carried out of the port area by a contracted biosecurity dive team. These surveys are commissioned by and reported to GDC and Ministry of Primary Industries (MPI).

Mediterranean fanworm (*Sabella spallanzanii*) has been recorded at several locations on concrete walls, the training wall and piles around the port and inner harbour. Locations recorded up to November 2016 are shown below in Figure 3[4].

Fanworm have been recorded in the most recent biosecurity survey, carried out in January 2020. A biosecurity report of the 'marina area' dated 21/01/2020 to Ministry of Primary Industries, provided by GDC, records 13 *Sabella* from the Gisborne Harbour (MPI Notification Number REW14544gRESP). The survey identifies 10 records from new marina pontoons which were established by GDC recently, and 3 from piles. This most recent survey did not include the port area, only the inner harbour. No updated plan of the fanworm locations has been provided by GDC at this point that would allow further records to be added to Figure 3 of the EWQR. The latest results which show a rapid colonisation of new structures placed within eh marina, suggest there is a viable reproducing population of fanworm in the harbour.

Biosecurity risks associated with the proposed application activities are discussed in section 4.5 of this report.

[4] Lass, H (Bay of Plenty Regional Council) (2016). "*Re: Mediterranean Fanworm (Sabella spallanzanii) Locations*' Message to L Easton (Gisborne District Council). 15 November 2016. Email

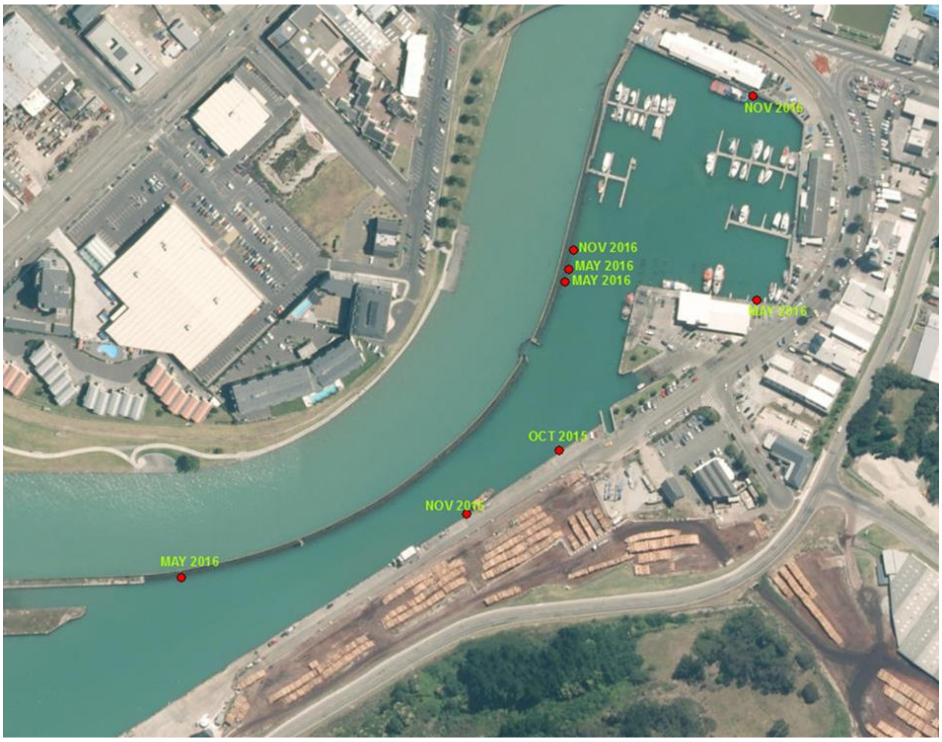

Figure 3: Reported Mediterranean Fanworm (*Sabella spallanzanii*) locations

3.2.3 Intertidal Surveys

3.2.3.1 2017 Wharf 6 and 7

A survey of intertidal marine habitat and biota beneath the Wharf 6 and Wharf 7 area was undertaken in May 2017[5] by 4Sight. This involved visual inspection of exposed intertidal substrates which included wharf piles and mudstone bedrock, to record macroinvertebrates. Representative photographs of this area taken as part of the 2017 study are presented in Appendix A.

Sub-tidal biota was also inspected on old 'crevice collectors' and spat rope that was found suspended from these wharves. Photographs of these are also shown in Appendix A. The crevice collectors are tiers of plywood plates that provide refuge and settlement substrate for marine life. These surfaces were heavily silted. Encrusting and sessile biota observed on the collectors and rope included solitary and compound ascidians and oysters. Mobile invertebrates included half crabs (*Petrolisthes* sp.), decorator crabs (*Notomithrax* sp.) and a small conger eel (*Leptocephalus vereauxi*). No pueruli, juvenile crayfish or shrimps were observed.

3.2.3.2 2017 Slipway

A survey of intertidal marine habitat and biota at the defunct slipway was undertaken in May 2017[6] by 4Sight. This involved visual inspection of exposed intertidal substrates to record macroinvertebrates in zones to be affected by the proposed slipway re-development.

The biota on the old structures included various algae (*Corallina* turf, *Colpomenia* sp., *Gelidium* sp., *Ecklonia radiata*); oysters (*Saccostrea glomerata*); chitons (*Sypharochiton pelliserpentis*); soft-shell sea slug (*Onchidella nigricans*); limpets (*Cellana radians*); blue mussels (*Mytilus edulis*); tube worms (*Pomatoceros caeruleus*); barnacles; and cat's eye

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[5] 4Sight Consulting (2017). *Gisborne Port: Wharf 6 and 7 Redevelopment. Eastland Port Ltd. Ecological and Water Quality Report*. Coastal Permit Application. September 2017

[6] 4Sight Consulting (2017). *Gisborne Port Slipway Redevelopment. Eastland Port Ltd. Ecological and Water Quality Report for Consent Application*. September 2017

snails (*Lunella smaragdus*). The latter gastropod species was particularly noticeable for its abundance and wide range in size which included large snails of up to 4-5 cm shell width. The 2018 resource consents for the re-development of the slipway require relocation of cat's eye snails to adjacent suitable habitat within the port environs.

This biota appeared 'healthy' and was comprised of common species. Representative photographs of the biota are included in Appendix B.

3.2.4 2017 Subtidal Sediment Survey

As part of 2017 field investigations noted above, samples of seabed sediment were collected close to the old slipway for assessment of contaminant levels in surficial sediment. Incidental to this exercise, the residual sediment sampled was processed for biota. The biota was beyond the potential footprint of effects related to the slipway proposal, and it was not intended or deemed necessary that this sampling provide a comprehensive or quantitative description on the benthic fauna. The method used provided a rapid bioassessment of community type on the local soft substrate, and an indication of the relative abundance of dominant taxa (see Appendix C).

Samples of soft seabed were collected at three sites to the west of the slipway in an area not within the present port maintenance dredging footprint. The samples reflect the broad nature of soft sediment community which occurs in this western pocket of the port basin.

That sampling indicated a limited benthic macroinvertebrate fauna. Seven marine bristle worm (polychaete) taxa were recorded. Only two species were found in the samples (*Heteromastus filiformis* and *Cossura consimilis*). A small number of the introduced bivalve rice shell (*Theora lubrica*) were present as were amphipod crustaceans, cumaceans and isopods. Diversity ranged between seven and nine taxa per sample. Taxa were common to soft textured sheltered marine habitat and not of types considered to be rare or otherwise ecologically notable, and diversity and abundance were low.

3.2.5 The Port as Juvenile Crayfish Habitat

The port has long been recognised to periodically host significant numbers of very young New Zealand red rock lobster (*Jasus edwardsii*). These settle seasonally into the port, mostly on the hard structures and natural papa rock batters beneath the existing Wharf 6 and 7 area where they may remain for a period of months. The context and significance of this settlement, has been the subject of detailed assessment, reporting and discussion in resource consent applications by Eastland, most recently the Wharf 6 and 7 redevelopment consent applications and related council hearing[7,8,9].

These reports include information establishing why and when this crayfish settlement happens, the specific habitat it occurs on, and its ecological context in relation to crayfish population dynamics in the wider crayfishery beyond the port. The information also includes opinions on the scientific significance of the settlement. In summary, juvenile crayfish settlement peaks in the winter/spring period; is highly variable year on year and may not occur at all in some years; is confined largely to a small area beneath the transition between Wharf 6 & 7; is likely to sustain high mortality due to the sub-optimal nature of the settlement habitat; is unlikely to be important in terms of supplying young crayfish to the wider coastal fishery beyond the port; and is considered to be of some scientific interest largely because it provides a sheltered location to 'harvest' juvenile crayfish for experimental purposes.

On 27 August 2018, having considered the above reports and assessment related to juvenile crayfish, Independent Commissioners decided to grant consent to redevelop Wharf 6 and 7 and to carry out capital and maintenance dredging related to that port work[10]. The consents were granted subject to consent conditions that require artificial

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[7] Jeffs, A (2017). *Permanent devices to promote the settlement of post larval lobsters in Gisborne*. Prepared for 4Sight Consulting. August 2017

[8] Jeffs, A (2018). *Review of artificial structures for promoting the settlement of post-larval lobsters in Gisborne*. Prepared for 4Sight Consulting. May 2018

[9] Jeffs, A (2018). *The settlement of post larval lobsters in Gisborne*. Prepared for 4Sight Consulting. May 2018

[10] Gisborne District Council. *Wharf 6 and 7 Consent. Decisions following the hearing of two applications for resource consent under the Resource Management Act 1991. 27 August 2018*

juvenile crayfish habitat to be established. The granted consents are currently the subject of appeals to the Environment Court and Court-assisted mediation and discussions between Eastland and the relevant appellants are ongoing. While effects on juvenile crayfish are specifically the subject of the appeal, Eastland remains supportive of the retention of conditions that require replacement artificial juvenile habitat. Eastland has prepared a proposed artificial habitat design which has been the subject of expert assessment by marine ecological experts and preliminary pilot trials are continuing in 2020. It is noted that these artificial habitats, which are called 'pipe collectors' to differentiate them from more conventional juvenile crayfish settlement devices called 'crevice collectors', are specifically designed to limit sediment intrusion into the voids (pipes) which the juveniles enter for refuge. In this respect they incorporate a further mitigation response to what is intrinsically a high sediment deposition locality.

As for the hard surface habitats around the port, the pipe collectors are not directly impacted by the proposed maintenance dredging activities.

3.2.6 Ecology of Areas Beyond the Port

Areas beyond but near to the port basin can be broadly divided into areas of the Port Navigation Channel (PNC) to the west beyond Butlers Wall and areas to the southeast toward Kaiti Reef. These are discussed below.

3.2.6.1 Habitat of the Navigation Channel and to the West

The PNC and its approaches and adjacent zones were surveyed by Cole et al (1997)[11]. That report records as one of its purposes '*a SCUBA survey within and adjacent to the existing approach channe*l' and in its 'Methods' section comments that '*Reefs within the shipping channel*' were surveyed. The report comments in its Executive Summary '…*The reefs of the proposed approach channel and adjacent to the present approach channel have a limited fauna of encrusting organisms*…'.

The findings presented in the Cole's report remains broadly relevant because the prevailing physical conditions which are likely to govern and limit ecological potential in the PNC are unlikely to have changed.

The report records 11 spot SCUBA dives from this channel and adjacent area. The grid coordinates provided in the 1997 report for the sampling sites have been plotted below in Figure 4[12].

Biota reported included a range of macroalgae (brown, green and turfing red), sponges and bryozans. Small post juvenile crayfish (*Jasus edwardsii*) were also recorded.

The zones beyond the channel to the west are sandy nearshore areas and Waikanae and Midway surf beaches. These sandy substrate environments are exposed to high wave energy. The writer is unaware of published or anecdotal information that identifies specific marine resources in this sandy zone such as edible or otherwise important shellfish beds. The zone is reported to sustain high transport of sand and riverine sediment in littoral longshore currents.

[11] Cole, R., Dobbie, N., Healy, T., Hull, P., Purdue, S., Stevens, S. (1997). *Port Gisborne Dredging and Development AEE: Assessment of impacts on fauna and flora of areas affected by the expansion of Port Gisborne Ltd*

[12] Several of the locations are somewhat different to those shown in the plan in the original report (specifically sites 1b, 6, 7 and 9). However, the coordinates are consistent with the narrative in the report. The location of the reef areas is confirmed as that reported in the Marine and Earth Sciences (2016) report (refer Figure 4 of this EWQR).

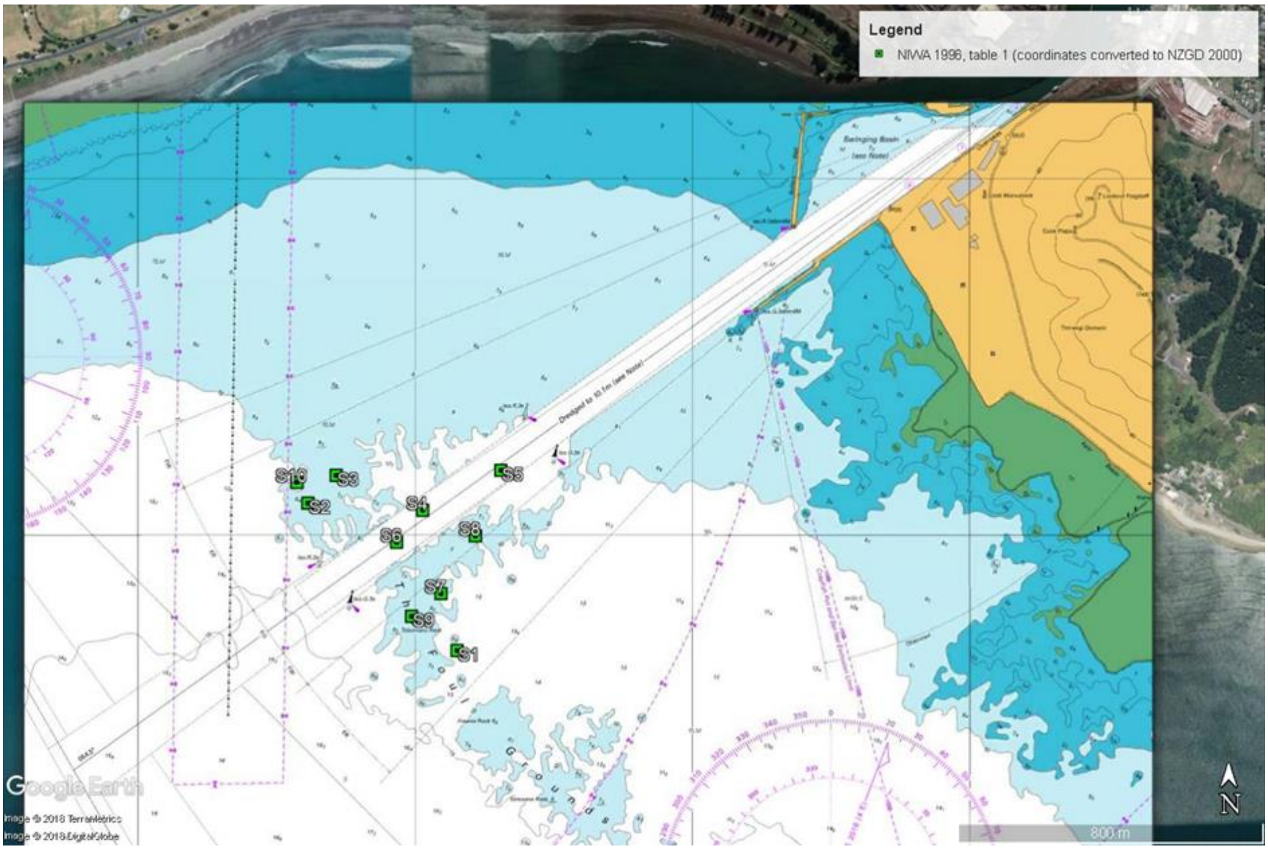


Figure 4: PNC and 'reef' sampling locations (Cole et al., 1997)

3.2.6.2 Previous Studies of Nearshore Habitat South East of The Port Breakwater

The near shore habitats to the immediate south east of the port breakwater, are fingers and stacks of patch reef interspersed with sand. These are effectively the subtidal part of the extensive shallow rocky reef area known as Kaiti Reef. This comprises a broad band of intertidal habitat which extends some distance offshore where reef and coarse substrates occur in water depths of up to 5m to 8m.

These are the nearest habitats of ecological interest to the port. They are, at least theoretically, the closest natural habitats that might potentially be influenced by dredging related plume effects. The habitat condition and the marine communities on this section of coastline, is likely to reflect the influence of wave energy and other factors which would mask any influences from small scale plumes associated with intermittent dredging operations.

This subtidal area was also studied by Cole et al (1997) who surveyed the rocky shorelines and adjacent shallow subtidal areas as part of an assessment of effects prior to the southern logyard expansion to its present footprint. This information, which was focused on areas seaward of the then proposed reclamation, provides a broad baseline picture of the habitat and biota that might still be expected. At the time of its collection, maintenance dredging was as much a routine part of port operations as it is now. Further, it is unlikely that storm events have diminished in their influence over this exposed shore.

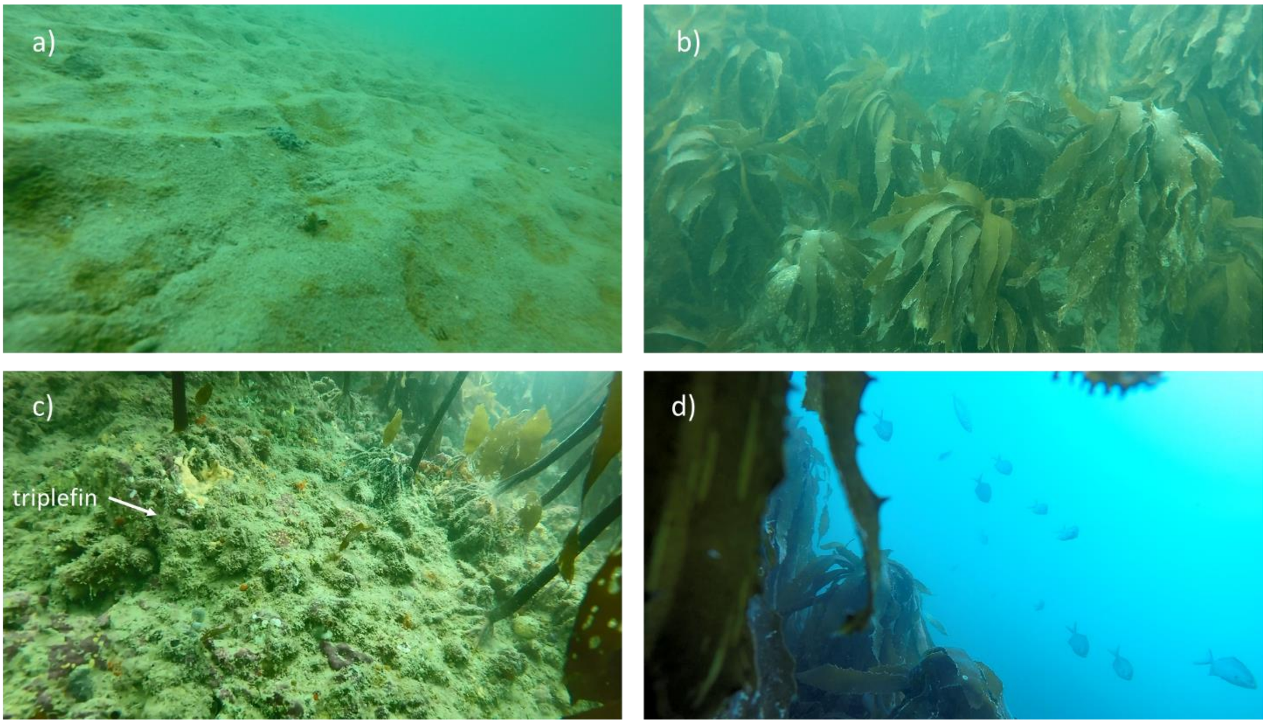
These authors recorded a wide diversity of biota including brown algae (four species); molluscs (12 species including snails, chitons and limpets); echinoderms (two species); crustacea (two species); other invertebrates (sponges and anemones); and 14 species of fish. Taxa included common kai moana species: urchins (*Evechinus chloroticus*); small paua (*Heliotis iris*); edible snails (e.g. pupu *Lunella smaragdus*); and small crayfish (*Jasus edwardsii*). The authors observed fine sediment covered most of the rock substrate at the time. Although specific conclusions regarding the then maintenance dredging programme cannot be offered based on this early work, it does suggest that a reasonably predictable and 'healthy' community was present at that time

As part of investigations by Keeley et al., 2002[13], related to consenting of the GDC wastewater outfall, a survey was undertaken in June 2002 of Tokomaru Rock, which lies about 250 m to the northwest of the southern end of the PNC, and of Temoana Rock, which about 750 m to the southeast of the PNC. The report provides some important findings that are still likely to be relevant as to the communities likely to be present and factors influencing habitat and biota. The report comments that reef communities at both Tokomaru and Temoana Rocks were subject to low light conditions, high loads of suspended particulates and regular disturbance by storms. Reef communities close to the wastewater outfall were reported as appearing to be particularly suppressed 'by a sandblasting effect from waves and suspended sediment'. Given the proximity of Tokomaru and Temoana Rocks to the PNC, these observations are likely also to be pertinent to the reef zones outcropping within and adjacent to the PNC.

3.2.6.3 March 2018 4Sight Sub-Tidal Habitat Survey South East of The Port Breakwater

In March 2018, 4Sight conducted a preliminary survey of the southern side of the port breakwater as well as the patch reef areas nearby. The survey collected visual information by a suspended GoPro camera. Sampling sites are shown in Appendix D. Two main habitat types were 'soft' sediment (sand), and rocky reef. Representative examples of the habitats are shown in Figure 5.

The habitat is mainly 'soft' sandy sediment (Figure 5a) in which holes and burrows made by small invertebrates were common and patches of surface microalgae were visible. The sand surface appeared relatively silt free at the time of survey. The rocky reef habitat supports kelps including *Ecklonia radiata*, *Carpophyllum* sp. and *Zonaria auriomarginata* (Figure 5b, 5e and 5f); encrusting species including coralline algae, sponges and ascidians (Figure 5c); and fish including Triplefins (*Forsterygion* sp.) (Figure 5c), sweep (*Scorpis lineolatus*) and koheru (*Decapterus koheru*)(Figure 5d). The breakwater also functions as a reef to support a similar suite of flora and fauna to that on the natural reef habitat (Figure 5f).



[13] Keeley, N., Barter, P. and Robertson, B. (2002). *Assessment of ecological effects on the seabed surrounding the Gisborne wastewater outfall: winter 2002*. Prepared for Gisborne District Council. July 2002. Cawthron Report No 735

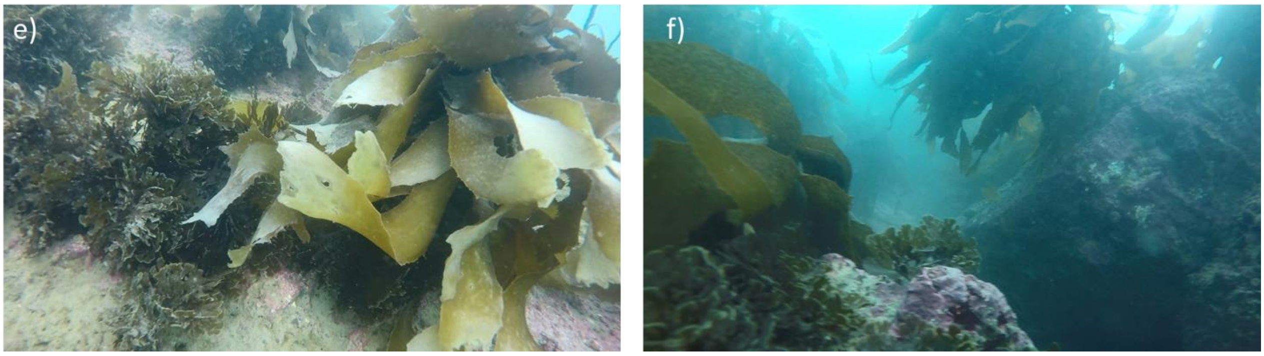


Figure 5: Subtidal Sand and Patch Reef Habitats South East of the Port (4Sight 2018)

The photographic information suggests a diverse range of biota associated with this local natural reef and breakwater. Looking at the basic habitat structure and its quality, there is an expectation that a detailed subtidal survey by SCUBA would record a more comprehensive array of species for different phylogenetic groups that would be consistent with the findings of the earlier survey by Cole et al (1997).

Key conclusions from the March 2018 observations were the absence of obvious or excessive fine sediment, silt, or organic debris, and the apparent health and diversity of the habitat notwithstanding the proximity of this area to port operations which include routine maintenance dredging and the discharge of stormwater from the Eastland southern logyard. The 2018 observations would suggest a physically robust habitat and associated marine community that has the capability to accommodate and respond to the strong physical influences which prevail at times (which are likely to include high wave energy, high natural sediment load and low light conditions).

3.2.6.4 September 2019 4Sight Inter-Tidal Habitat Survey South East of The Port Breakwater

4Sight undertook a survey of the exposed intertidal reef south east of the port navigation channel breakwater in September 2019. The three regions of the reef surveyed are identified below as 'Outflow' (the reef habitat closest to the Eastland Southern Logyard discharge); 'Western Kaiti' and 'Eastern Kaiti'. These intertidal zones are potentially in the zone of influence of the plume field from decant water from maintenance dredging in the PNC. The survey is detailed in Appendix E to this report.

Figure 6: Intertidal Sampling Areas South East of the Port (2019)

Each site covered slightly different parts of the shore. Specifically, due to access and the narrower shore at this point the 'Outflow' site was restricted to mostly the 'mid tide zone'; the 'Western Kaiti' site covered high, mid and low tide sites; and the 'Eastern Kaiti 'site covered the low and mid tide.

A summary of the taxa recorded at each site is presented below in Table 1 and species are identified where possible. In total 30 taxa were recorded. These were dominated by alga (18 taxa); snails (6 taxa); limpets (2 taxa); anemones (2 taxa); one chiton and one tube worm taxa. At each site the high tide was dominated by turfing coralline algae and bare rock; the mid tidal zone by the Neptune's Necklace alga (*Hormosira banksii*) and irregular patches of seagrass (*Zostera muellleri*); the low tidal zone was characterised by a variety of seaweeds. Overall the biota was predictable for this exposed reef of low relief in a high energy location. There was no obvious evidence of impacts from the port, such as accumulations of sediment or woody debris.

Figure 7 shows representative photographs from the intertidal survey habitats. These are identified as:

Figure 7a): 'Outflow' mid to upper site looking west along the Southern Logyard seawall

Figure 7b): 'Outflow' site mid intertidal showing eelgrass and tidal pool algae

Figure 7c): 'Western Kaiti' site closeup of high intertidal reef habitat (showing measuring quadrat)

Figure 7d): 'Western Kaiti' site mid intertidal reef habitat and gut

Figure 7e): 'Eastern Kaiti' reef low intertidal

Figure 7f): 'Eastern Kaiti' reef mid to low intertidal

3.2.6.5 Marine Mammals and Birds

There are no reported regular presence of marine mammals or coastal birds of particular value, interest or sensitivity at or near the port that would warrant specific consideration in relation to the proposed dredging activity or its actual and potential effects.

Table 1: Summary species list from the Kaiti intertidal reef

Taxa	Identifier	Scientific Name (where	Sampling Location		
			Outflow	Western	Eastern
Alga	Black encrusting algae		Y	Y	y
	Branching velvet weed	*Codium fragile*		Y	Y
	Brown seaweed	*Carpophyllum sp*			Y
	Brown seaweed	*Dictyota kunthii*			Y
	Carrageenan weed	*Gigartina clavifera*		Y	
	Common kelp	*Ecklonia radiata*			Y
	Coraliine algae (paint)	*Corallina sp*			Y
	Coralline algae (turfing)	*Corallina sp*	Y	Y	
	Encrusting velvet weed	*Codium convolutum*	Y	Y	Y
	Feathery red		Y	Y	Y
	Furry green		Y	Y	Y
	Neptunes Necklace	*Hormosira banksii*	Y	Y	Y
	Puff ball algae	*Colpomenia sp*	Y	Y	Y
	Sea lettuce	*Ulva sp*	Y	Y	Y
	Seagrass	*Zostera muelleri*		Y	
	Soft spongy green			Y	
	Thick green algae	*Bryopsis sp*	Y	Y	Y
	Zig zag weed	*Cystophora scaralis*			Y
Polychaete	Blue tube worm	*Spirobranchis caraniferus*		Y	Y
Anemones	Olive anemone	*Isactinia oilvacea*		Y	
	White striped anemone	*Anthothoe albocincta*		Y	
Gastropods	Catseye	*Lunella smaragdus*	Y		Y
	Small black snail			Y	
	Cooks Turban	*Cookia sulcata*			Y
	Oyster borer	*Haustrum sconia*			Y
	Spotted top snail	*Diloma aethiops*	Y	Y	Y
	Red mouthed whelk	*Cominella virgata*		Y	Y
Limpets	Common pulmonate limpet	*Siphonaria australis*		Y	
	Ornate limpet	*Cellana ornata*		Y	
Chitons	Green chiton	*Chiton glaucus*			Y
Total taxa	30		11	21	21

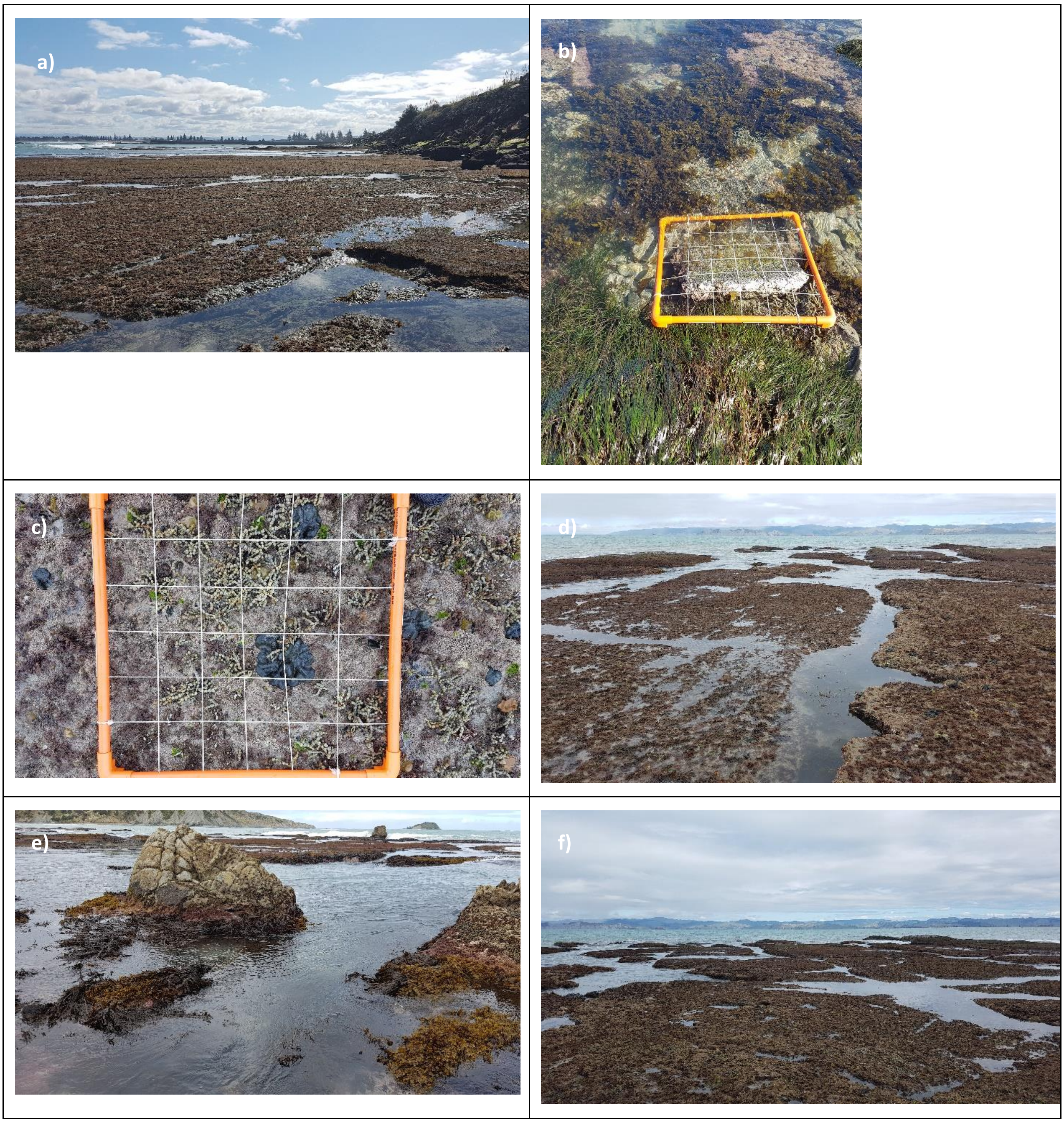


Figure 7: Intertidal Reef Habitats South East of the Port (4Sight 2019)

3.2.6.6 August 2019 4Sight Sub-Tidal Benthic Survey South East of The Port Breakwater

In August 2019, 4Sight undertook seabed sampling to the immediate south of Eastland Port seaward of the Kaiti reef system (within 1.5km of the port entrance) (See Figure 8 below). This location lies within the potential plume field of discharges from maintenance dredging operations at the port as well as from stormwater discharges from the Eastland Port southern logyard (the discharge point is approximately at the 'Outflow' location shown in Figure 6).

This benthic survey is fully reported in Appendix F of this report. The coarseness of the substrate constrained sampling. However, sediment texture and quality were able to be assessed from five sites identified in the **Error! Reference source not found.** sampling plan as P1, P6, P7, P16 and P17.

Parameters assessed included metals, total organic carbon and grain size. Surficial chemistry results are presented in Table 2. These are discussed below

Table 2 values are expressed in reference to three Guideline Values: TEL; ANZ DGV and ANZ DGV-High. These are explained below:

Threshold Effects Level (TEL)[14]: The **TEL** is a sediment contamination concentration at which a toxic response has started to be observed in benthic organisms.

Australia and NZ Guidelines For Fresh and Marine Water Quality (ANZ)-Default Guideline Value (DGV) and DGV High[15],[16]: These are toxicant default guideline values for aquatic ecosystems. Broadly, 'DGV' values represent a threshold below which there is a low probability of toxicological effect on marine organisms in sediment. DGV -High is a threshold above which there is a high probability of such effect. DGV's were published in the ANZECC 2000 guidelines and new and revised DGV's were published in 2018. However, there were no changes made in the 2018 to the numerical values for sediment contaminants listed in Table 2. They remain as published in ANZECC 2000.

Table 2: Sediment metal concentrations adjacent to the Kaiti Reef (All values mg/kg dry wt)

	P1	**P6**	**P7**	**P16**	**P17**	**TEL**	**ANZG DGV**	**ANZG DGV-high**
Arsenic	5.9	4.9	4.5	6.3	14.1	7.24	20	70
Cadmium	0.018	0.017	0.029	0.025	< 0.02	0.68	1.5	10
Chromium	4.7	4.2	4.4	4.9	3.5	52.3	80	370
Copper	3	2.6	2.7	3.6	2.6	18.7	65	270
Lead	2.9	2.3	2.3	3.3	3.3	30.2	50	220
Mercury	< 0.02	< 0.02	< 0.02	< 0.02	< 0.04	0.13	0.15	1
Nickel	5.1	4.7	5	5.6	3.5	15.9	21	52
Zinc	28	22	27	26	15.5	124	200	410

[14] MacDonald DD, Carr RS, Calder FD, Long ER, Ingersoll CG (1996) Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology 5:253–278

[15] ANZG. 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments. Canberra ACT, Australia. Available at https://www.waterquality.gov.au/anz-guidelines

[16] https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/toxicants#metals-and-metalloids

Figure 8: Kaiti Reef offshore benthic sampling sites P1, P6, P7, P16 and P17

Metals

All sediment metals concentrations, except arsenic at P17, were low and fell below the relevant guideline values. The arsenic value at P17 was approximately double the threshold effects level (TEL) values of MacDonald et al. (1996), but well below ANZG 2018 default guideline values (DGV's). The slightly higher level of arsenic recorded at P17 may be related to the higher levels of organic material recorded at this site.

Total Organic Carbon

Determination of Total Organic Carbon (TOC) is an important part of environmental characterisation of sediments. TOC in marine sediments has multiple potential sources, although most marine organic carbon comes from photosynthetic fixation of CO_2 by phytoplankton. Through the direct effect on redox potential (the measurement of the tendency of an environment to oxidize or reduce substrates) of sediments, TOC can have a major influence on chemical and biological processes occurring in sediment, including regulation of the behaviour (and toxicity) of metals and other contaminants.

There are no nationally accepted guideline values for TOC in marine sediments. Instead, values are compared to the classification system of Robertson and Stevens (2007)[17] that was developed for estuarine systems (Table 3).

Table 3: Classification of sediment enrichment according to Robertson and Stevens (2007)

	Very Good	Good	Fair	Poor
TOC percentage	0-1%	1-2%	2-5%	>5%

Recorded sediment TOC concentrations at the sites adjacent to the Kaiti Reef are presented in Table 4.

[17]Robertson B, Stevens L (2007) Waikawa Estuary 2007. Fine Scale Monitoring & Historical Sediment Coring.

Table 4: Kaiti Reef sediment TOC concentrations (%)

	P1	P6	P7	P16	P17	P1
Total Organic Carbon (%)	0.06	< 0.13	0.07	0.09	0.25	0.06

TOC concentrations at all the Kaiti Reef sites, also fall within the 'very good' category of Robertson and Stevens (2007). One site (P17) had a slightly higher level of TOC than the other sites but this remained well within the 'very good range'.

Particle Size

The particle size distribution of each of the Kaiti Reef sites is presented in Figure 9 below.

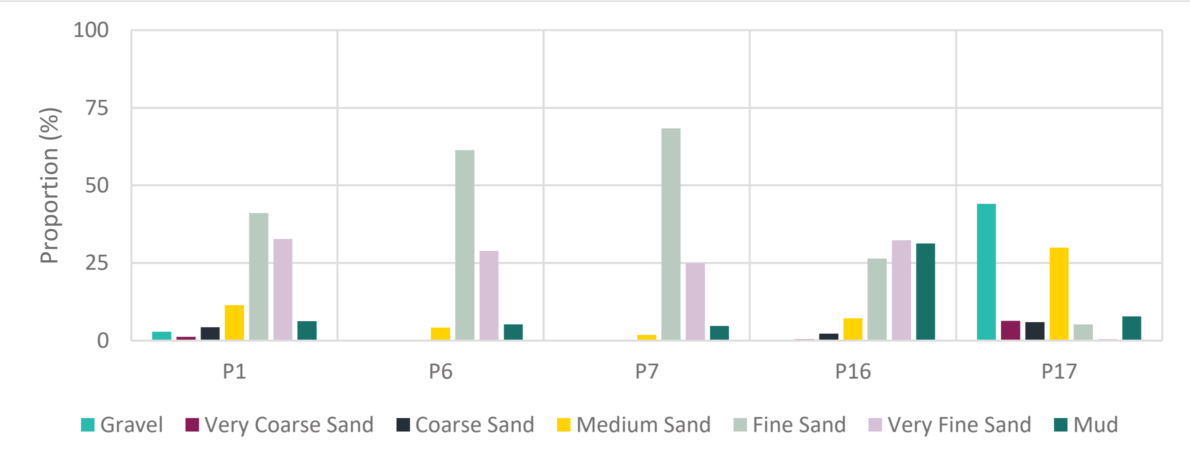


Figure 9: Kaiti Reef particle size distribution

The samples P1 to P16 were comprised predominantly of fine sand and very fine sand and varying proportions of mud and medium sand. Coarse sand, very coarse sand and gravel were minor components of these samples. The particle size distribution of P17 was notably different compared to the other samples, being comprised predominantly of gravel and medium sand.

3.3 Water Quality of the Port Area

3.3.1 Tairawhiti Plan Classification

Expectations for water quality at the port and ODG, and impacts on that water quality, can be assessed in relation to a water quality classification, the standards for which are presented in the Tairawhiti Plan. The water quality classifications applying to the Port, PNC and ODG are shown in Figure 10. Details of the standards that apply to the water classes are described in Table 5.

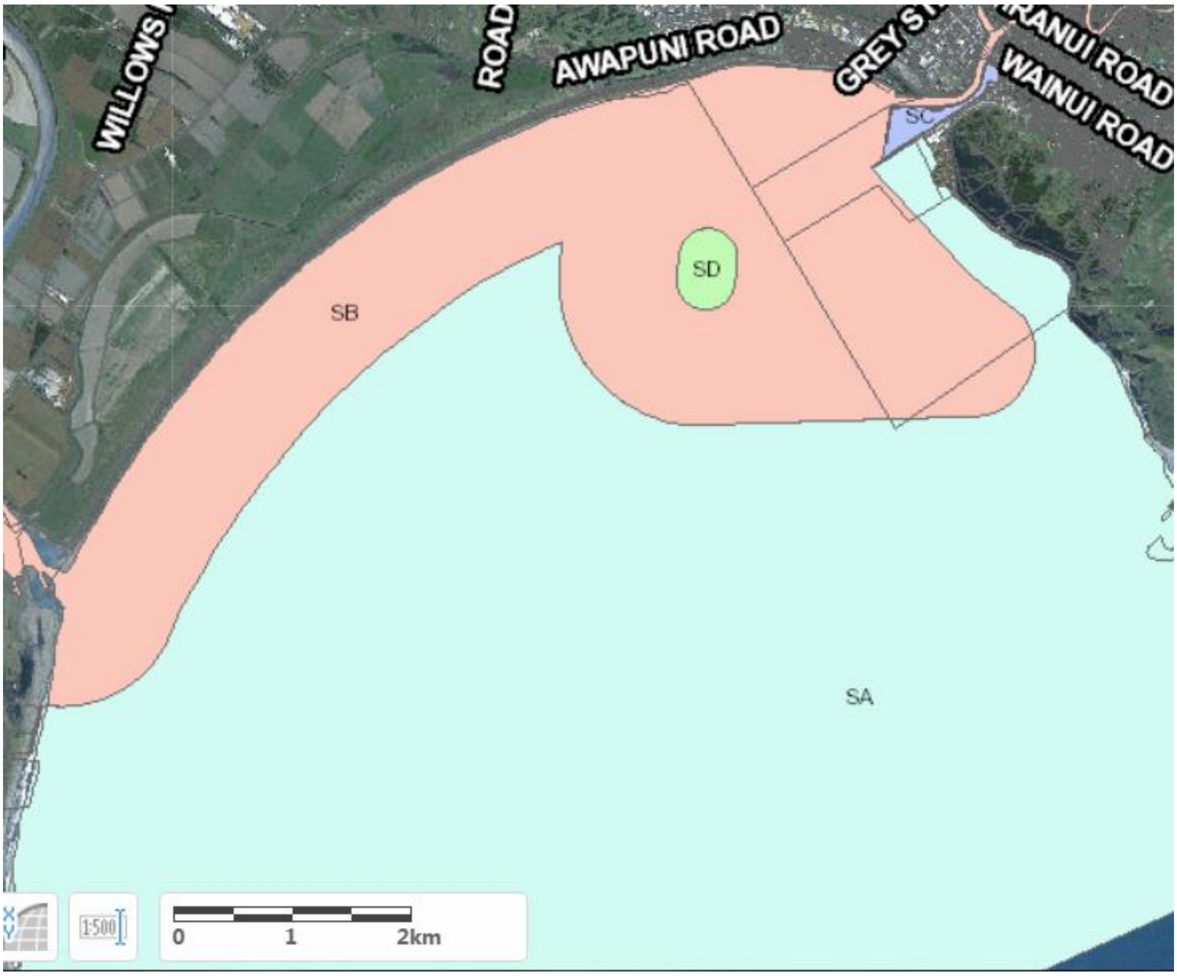


Figure 10: Water Classifications

There are four applicable standards to the waters in and adjacent to the port. In order of most to least relevance at the port, PNC and ODG, these are: SC, SB, SA and SD. SC and SB are most relevant to the locations in which the dredging activities are proposed, and SA is relevant to the ODG.

- SC encompasses the PNC inside the Butlers Wall as well as the VTB, berths and inner harbour.
- SB covers the PNC beyond the Butlers Wall as well as nearshore coastal areas.
- SA covers the nearshore waters to the southeast of the port breakwater as well as the open coastal waters which include the ODG. This SA area is typically of a naturally higher quality, which is not subject to the same range or intensity of influences as the port area/navigation channel.
- SD is a mixing zone for the GDC municipal treated wastewater discharge.

Class SB and SC differ only in respect that SB has a requirement to protect bathing water quality.

Class SA differs from SB in that it also requires kai moana not to be contaminated, hence its application to the nearshore Kaiti Reef waters which are used for the collection of shellfish and potentially other species for food.

Table 5: Water Classification Standards

Requirements	SA	SB	SC
The quality of the Class XX waters shall conform with the following requirements:			
a. The natural temperature shall not be changed by more than 3 degrees Celsius	X	X	X

b.	The natural pH of the waters shall not be changed by more than 0.1 unit and at no time shall be less than 6.7 or greater than 8.5	X	X	X
c.	There shall be no destruction of natural aquatic life by reason of a concentration of toxic substances nor shall waters emit objectionable odours	X	X	X
d.	The natural colour and clarity of the water shall not be changed to a conspicuous extent	X	X	X
e.	Aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants, and	X		
	The water shall not be rendered unsuitable for bathing by the presence of contaminants	X	X	

The SC Standard covering the port reflects the wide range of influences on water quality. These include ship movements and dredging; stormwater discharges from the land; other activities from the upper harbour (the marina and small commercial and recreational boat activities) as well as the significant influence of the Turanganui River and the Kopuawhakapata Stream.

The SB standard reflects some similar influences and particularly that from dredging and the Turanganui River discharge. It is unclear as to why the part of the PNC seaward of Butlers Wall is included in this classification zone.

3.3.2 Water Quality at the Port

As noted, the port area is influenced by routine ship and tug movements and catchment storm events (including natural discharges via the Turanganui River and Kopuawhakapata Stream, and discharges from the Southern Logyard). Otherwise and typically, water quality at the port is influenced by relatively 'clean' coastal waters. Even at times of apparently good water quality in the port basin, it is not unusual for the waters of the adjacent Turanganui River on the northern side of the training wall to be highly turbid. This situation is shown in Figure 11, which is a drone photograph taken early on a flood tide on 05 July 2017.

3.3.2.1 Port Activities Influencing Water Quality

A further drone photograph is presented as Figure 12, which shows a typical example of the influence of tug activity. In the photograph, which was taken at the same time as that in Figure 11 in otherwise 'clear' port waters, the tug wash from a vessel being berthed at Wharf 8 has generated a heavy, conspicuous plume of turbid water from the main wharf extending across to the old slipway and over much of the port basin. Such activity at Wharf 7 can have similar effect and generate such plumes which also include Wharf 6 and adjacent areas. These influences permeate the entire inner port area, VTB and berth pockets and effectively become the background state at such times.

3.3.2.2 Catchment Influences on Water Quality

Riverine sediment load has been documented for the Turanganui River. The River has been reported to carry up to 3 to 8 kg/m^3 of sediment during storm events (MetOcean, December 2017; page 29)[18]. This equates to suspended sediment concentrations of between 200 to 550 times typical background conditions during non-storm periods.

[18] Met Oceans Solutions Ltd (2017). *Eastland Port Dredging Project. Morphological Model Validation.* December 2017

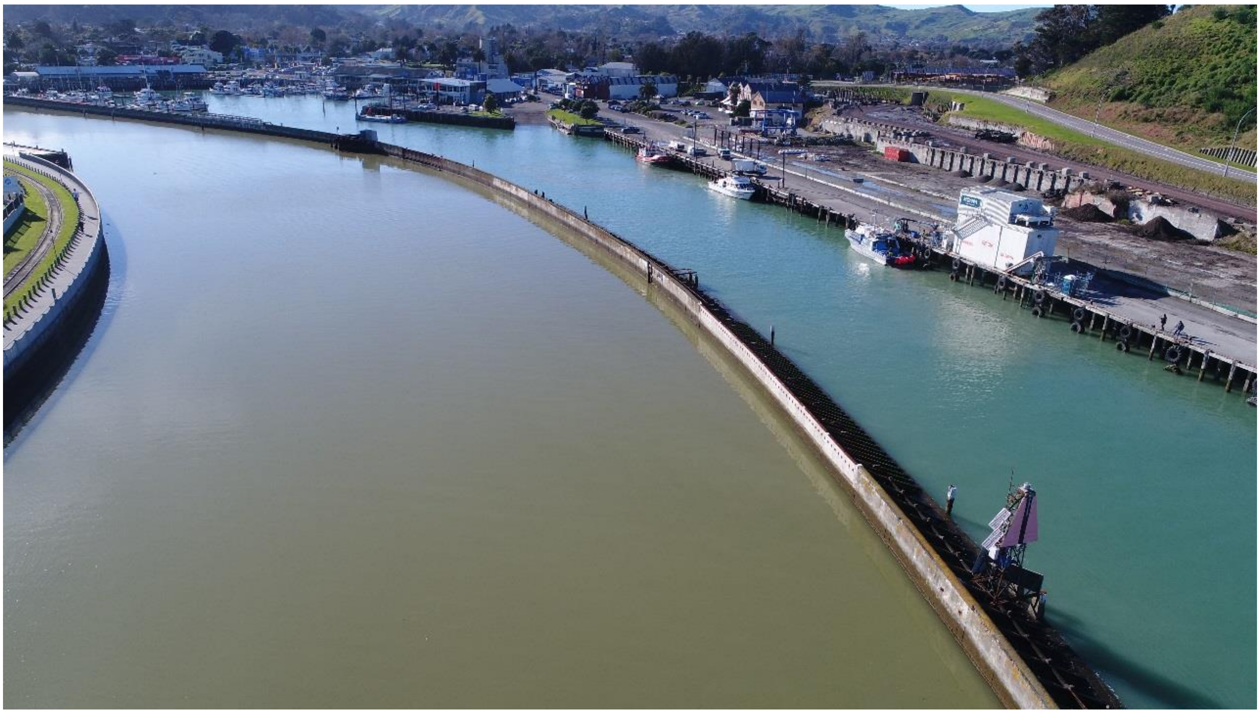


Figure 11: Turanganui River and inner port area (photo taken 05/07/2017, 10:37am).

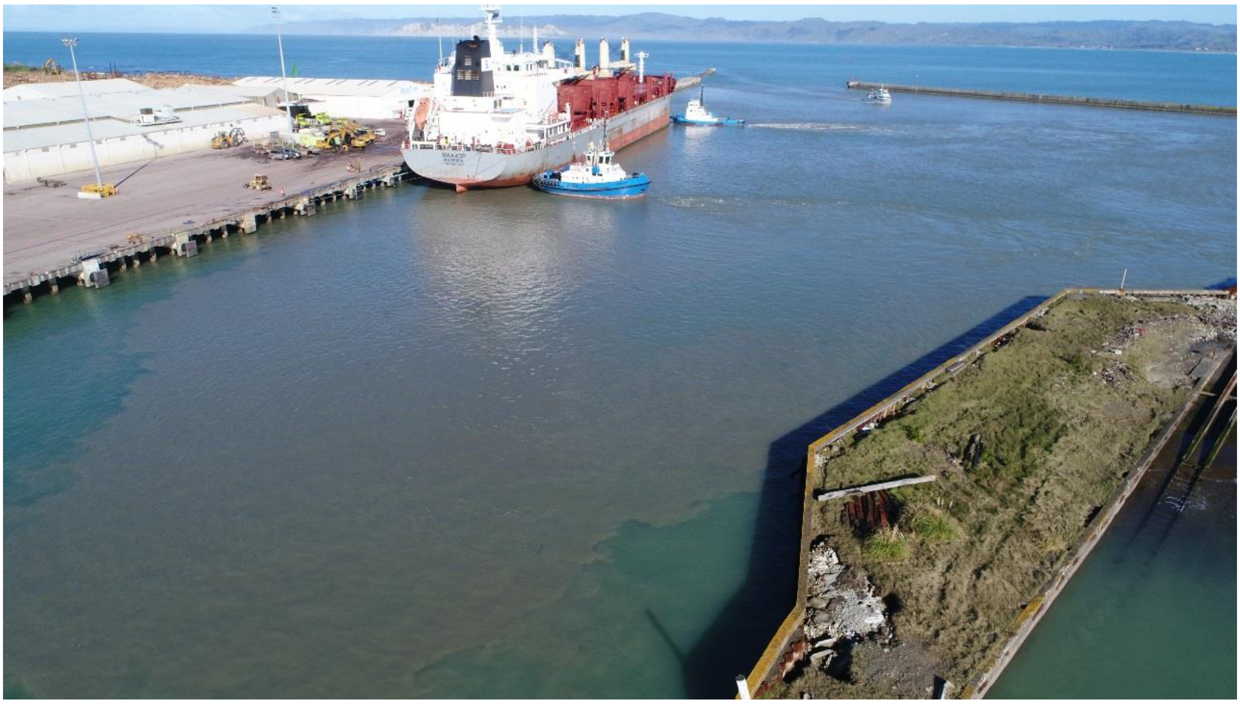


Figure 12: Turbidity generated by tug activity within the port basin (photo taken 05/07/2017, 10:38am).

Such influence is illustrated by a storm event in late May 2017 which resulted in high sediment load being discharged from the Turanganui River, which then entered the port area through natural tidal movement. This is not an unusual occurrence. Water sampling was undertaken by 4Sight the day following that event to document the 'natural' range in some parameters experienced at the locality. There was no shipping movement that day or other port related activity that could have significantly influenced port suspended sediment load. Water sampling was undertaken at five sites within the harbour basin (Sites 1- 5) and one site (Site 6) was also sampled outside the harbour basin (located 150 metres beyond the Butlers Wall) as a background site. Results are presented in Table 6.

In that event, vertical water clarity as measured by secchi disk, was very low within the port basin. Vertical clarity was in the range 18-19.5 cm. By comparison, background vertical clarity beyond the harbour was 94 cm.

During the May 2017 event, suspended sediment levels within the port basin were in the range 130-230 g/m^3 and turbidity in the range 85-160 NTU. Background suspended sediment and turbidity beyond the harbour was 20 g/m^3 and 5 NTU respectively.

The results also show the reduced salinity throughout the port at that time (salinity range 12.8-16.2 ppt) compared to the background site (salinity 28.5 ppt).

Table 6: 28 May 2017 Water Sampling Results (Sites 1-5=harbour basin; Site 6 =background beyond harbour).

Parameter	**Unit**	**Sampling Site**					
		1	**2**	**3**	**4**	**5**	**6**
Vertical Clarity (Secchi Disk)	cm			18	19.5	19.5	94
Total Suspended Solids	g/m^3	230	260	170	150	130	20
Turbidity	NTU	150	160	85	110	85	5.6
Salinity	ppt	12.8	16.2	15.9	13.6	14.8	28.5

These examples illustrate the range in water quality and the lowered quality of the harbour waters at times due to natural storm events. The elevated suspended sediment levels at Sites 1-5 in Table 6, can be compared with 'background' concentrations in the main turning basin during or shortly after rainfall as recorded as part of monitoring of the Eastland Port southern logyard discharge. That data (which is reported to Council on a regular basis) shows a total suspended solids median concentration of 15 g/m^3 and range of 3 to 89 g/m^3 for 47 background sampling results collected between March 2017 and July 2019 within the VTB[19]. These results confirm a highly variable water quality in respect of suspended sediment, with the upper concentrations occurring in the harbour being more than 10 times this median.

The frequently elevated suspended solids and turbidity and reduced visual clarity due to natural events and routine authorised activities within the port confines, are important aspects of the existing environment when considering part (d) of the SC water classification detailed in Table 5: Water Classification Standards

above. It is clear that existing permitted operations, as illustrated by Figure 12, cause the water quality standard (e) (i.e. '*The natural colour and clarity of the water shall not be changed to a conspicuous extent*) to be exceeded.

3.4 Port Sediment Quality

3.4.1 Maintenance Dredging: Seabed Physical Characteristics and Sediment Quality

Near surface seabed sediments within the port basin are reported to be in the range of 80% cohesive material (silt 60% and clay 20%) and 20% sands and in the PNC beyond Butlers Wall, 80% sands and 20% fines (MetOcean, November 2019 -Table 2.1, page 20)[20].

Since 2006, including more recently, in accordance with the current consent conditions for maintenance dredging, sediments are sampled annually from three sites within the Port and are analysed for a range of heavy metals [21]. The testing information is summarized in Table 7: Sediment metals concentrations from annual monitoring over the period 2006 to March 2019. Table 7: Sediment metals concentrations from annual monitoring over the period 2006 to March

[19] 4Sight Consulting (2019). *Eastland Port Southern Logyard. Water Sampling Report, July 2019*. Submitted to Gisborne District Council

[20] MetOcean Solutions (2019). *Eastland Port Dredging Project. Eastland Port Dredging Plume Modelling*. November 2019

[21] 4 Sight Consulting (2017). *Maintenance Dredging Annual Monitoring. For Eastland Port Ltd. Sediment Monitoring and Elutriate Testing.* April 2017. Prepared for Eastland Port Ltd.

2019. Results are compared with consent limits/ANZECC 2000 Interim Sediment Quality Guideline-Low values. (All values mg/kg; metals Total Recoverable)

Results are also compared with the ANZECC 2000 Interim Sediment Quality Guideline (ISQG)[22] which are represented by the 'Consent Limits' column in the table. The ANZECC (2000) Guideline provides two thresholds for the description of the pollutant status of the in-situ sediment: a 'Low Value' and a 'High Value'. The 'Low Value' is a level below which toxicity effects on biota are unlikely (note these 'low' and 'high' values are the same values and are synonymous with the ANZG DGV and ANZG DGV-High values presented in Table 2 of the EWQR).

Results confirm that all sediment testing has shown metals concentrations are well below the specified resource consent limits and the ANZECC (2000) ISQG-Low Value. Taking the results as indicative of the surficial sediments generally in the port area and which are likely to be dredged, the material is considered unpolluted and suitable for offshore disposal.

3.4.2 Resource Management (Marine Pollution) Regulations

Disposal of the dredged material is also subject to the Resource Management (Marine Pollution) Regulations 1998. Schedule 3 Part 1 of those regulations identifies technical information to be provided which is additional to that required under section 88 of the Resource Management Act.

Of relevance to ecological and water quality matters related to the port area existing environment, Schedule 3 of the Regulations requires the following information (paraphrased):

- A characterisation of the dredged material that includes physical, chemical, biochemical and biological properties (Clause 2(b), Schedule 3);
- Toxicity (Clause 2(c), Schedule 3);
- Physical, biological and chemical persistence (Clause 2(d), Schedule 3);
- Accumulation and biotransformation in biological materials or sediments (Clause 2(e), Schedule 3);
- Sources of contamination in the dredged material (Clause 4, Schedule 3);
- Physical, chemical and biological characteristics of the water column and seabed (6(a));

These assessment criteria can be satisfied by the available information and are addressed in the body of this report and more specifically discussed below. The Regulations also require information in relation to effects assessment and management, as well as assessment of the disposal site. Such matters are covered in sections 4.0 and 3.5 of the EWQR respectively.

3.4.2.1 Characterisation of the Dredged Material

Physical: The material to be maintenance dredged is largely sourced from the Turanganui River and the Kopuawhakapata Stream. Maintenance dredged material is predominantly silt and fine sands (Worley Parsons, 2014) and (as described below) is similar in texture to the ODG site.

Chemical: The quality of future maintenance dredgings can be predicted with reasonable confidence in relation to the concentrations of heavy metals (cadmium, chromium, copper, lead, mercury and zinc) documented to date from port monitoring (see Table 7). Concentrations of those metals are in all cases well within the appropriate ANZECC ISQG-'Low Values' limits below which toxicity effects on biota are less likely. The future dredgings are considered likely to remain unpolluted and of an appropriate quality for disposal to a similarly fine grained, highly dispersive site offshore.

Biochemical: The maintenance dredged material is not likely to have accumulated significant organic material or be significantly influenced by industrial or other waste. It is mostly inorganic (silts and fine sands) and its chemistry is likely to typify the sediment load from rivers in general around Poverty Bay. The dredged material is not considered to pose a risk to the receiving waters or disposal the site in terms of its biochemical properties.

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[22] Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand (2000). *Australian and New Zealand guidelines for fresh and marine water quality. Volume 1*.

Biological Properties: The sediment to be removed by maintenance dredging, is, by definition, recently deposited and frequently excavated or disturbed. The biology of the sediments within the outer harbour adjacent to the turning basin (and therefore outside the dredged zone) appears to be limited (see section 3.1.4). It is very unlikely that surface sediments within dredged areas will show greater biodiversity. This is likely to remain the case into the future. Biological properties are not considered to be of concern.

Toxicity: Toxicity risk for sediment associated with chemicals of recent anthropogenic origin, can be complex and is a function of exposure of biota to bioavailable compounds which is itself influenced by the complex suite of physical, chemical and biological factors. However, sediment monitoring data related to in-situ heavy metal concentrations (which provides a first level screen as to a possible toxicity concern) indicates these sediments are not toxic. Other properties such as significant oxygen demand being generated during dredging or on the release of sediments at the dumping site, is unlikely given frequency of sediment disturbance and the predicted low concentrations of accumulated organic matter. Given that the known source of sediment (mainly the Turanganui River or more specifically the Taruheru and Waitama Rivers which join to form the Turanganui some 1200m upstream) is non industrial, it is considered that the material does not contain qualities that would render a toxicological risk associated with the excavation or disposal of the material.

Persistence: The sediments are considered unlikely to contain persistent and potentially bioaccumulative chemicals such as polyaromatic hydrocarbons and organochlorines above trace levels.

Accumulation and Biotransformation: Accumulation and biotransformation are not considered to be relevant risk factors in relation to the proposed dredged material. The dredging site has been subject to regular removal of near surface silts and sands. In addition, the dredged silts are of a predominantly clean nature which are derived from non -industrialised catchments.

Sources of Contamination: The catchments include farmland; urban, commercial, and residential areas; and a marina. These uses will generate some contamination entrained in stormwater. If the port was not present, the maintenance dredged material from the Turanganui River and Kopuawhakapata Stream would still discharge their load of sediment and any other contaminants, to the nearshore coastal environment. Being ‘downstream’, the port area provides a location where a proportion of that ‘contaminant load’ settles out on the seabed and is subsequently moved via maintenance dredging to the ODG.

The primary activity on the port land, being log storage, generates some site-specific contamination in the form of sediment and small quantities of natural wood residues (e.g. particulates and dissolved compounds such as natural wood leachates). However, these activities are themselves the subject of specific resource consents which control (via consent conditions) the quality of discharges to ensure that the local receiving environment is not adversely affected.

It is considered that subject to appropriate management (discussed below) the potential sources of contamination do not impose any material concerns in relation to the quality of the dredged material.

Table 7: Sediment metals concentrations from annual monitoring over the period 2006 to March 2019. Results are compared with consent limits/ANZECC 2000 Interim Sediment Quality Guideline-Low values. (All values mg/kg; metals Total Recoverable)

Turning Basin	**2006**	**2008**	**2012**	**2013**	**2014**	**2017**	**2018**	**2019**	**Consent Limits**
Arsenic	nv	nv	nv	nv	nv	6.6	7.7	6.4	20
Cadmium	0.12	0.07	0.07/0.079	0.085	0.073	0.079	0.079	0.07	1.5
Chromium	22.1	19	13.9/16	16	10.6	17.5	15.4	14.8	80
Copper	15.7	12	11.2/14.9	15.3	12.3	18.1	18.0	15.2	65
Lead	10.3	7.9	7.9/9.6	8.6	9.1	9.2	9.3	8.4	50
Mercury	0.06	0.047	0.04/0.059	0.046	0.036	0.059	0.05	0.04	0.15
Nickel	nv	nv	nv	nv	nv	19.0	19.0	15.2	21
Silver	nv	nv	nv	nv	nv	0.07	0.06	0.058	1.0
Zinc	63.5	48	47/57	60	56	59	62	58.4	200
TPH	nv	nv	nv	nv	nv	<110	<80	<80	nv
Butlers Wall	**2006**	**2008**	**2012**	**2013**	**2014**	**2017**	**2018**	**2019**	
Arsenic	nv	nv	nv	nv	nv	7.0	7.4	5.8	20
Cadmium	nv	nv	0.089/0.094	0.071	0.068	0.084	0.099	0.067	1.5
Chromium	nv	nv	16.1/16.2	13	12.9	18.6	14.3	14.4	100
Copper	nv	nv	12.4/12.6	10.8	10.7	18.5	14.8	10.3	65
Lead	nv	nv	9.7/10	7.4	7.4	9.9	8.2	7.0	50
Mercury	nv	nv	0.06/0.046	0.34	0.053	0.07	0.05	0.04	0.21
Nickel	nv	nv	nv	nv	nv	19.8	17.3	14.1	21
Silver	nv	nv	nv	nv	nv	0.08	0.06	0.05	1.0

Zinc	nv	nv	53/55	49	49	61	58	48	200
TPH	nv	nv	nv	nv	nv	<110	nv	nv	nv
Channel	**2006**	**2008**	**2012**	**2013**	**2014**	**2017**	**2018**	**2019**	
Arsenic	nv	nv	nv	nv	nv	nv	6.9	5.5	20
Cadmium	0.03	0.031	0.024/0.025	0.029	0.041	nv	0.055	0.045	1.5
Chromium	10.4	8.7	8.5/8.8	9.9	10.9	nv	13.2	10.8	100
Copper	4.6	3.9	3/3.1	5.7	6.7	nv	11.5	7.0	65
Lead	14.8	4.1	4.7/4.7	5.5	6	nv	7.1	5.7	50
Mercury	0.02	0.015	0.021/0.018	0.036	0.030	nv	0.05	0.04	0.21
Nickel	nv	nv	nv	nv	nv	nv	15.7	11.6	21
Silver	nv	nv	nv	nv	nv	nv	0.05	0.04	1.0
Zinc	35.2	28	31/30	36	41	nv	48	40	200
Notes		nv = no value; Channel not sampled in 2017 due to dredge operating at time of survey							

3.5 Offshore Disposal Ground (ODG)

3.5.1 ODG Seabed Physical Characteristics and Quality

The physical character of the seabed within the general area is well documented and is reported to be a silt-mud blanket of more than 50% mud in the 12 m to 15 m isobath (MetOcean, December 2017; page 22).

4Sight undertook a survey of the sediment quality and texture of sediments at the ODG in August 2019. Those results are summarised below and are presented in full in Appendix F of this report.

3.5.1.1 August 2019 Survey (4Sight)

The ODG which is the proposed disposal site for the Eastland port maintenance dredging lies some 4km to the west of the port in between 18m to 20m water depth. Historically the ODG receives in the order of 100,000 m^3 per annum of port dredgings[23] resulting from the maintenance of necessary operational depths within the port (although as previously noted this volume can be variable) and consent is sought for up to 140,000 m^3 per annum.

In addition to the Turanganui River (or more specifically the Taruheru and Waitama Rivers) which discharges 0.7 million tonnes annually, the ODG is also influenced by the Waipaoa River, about 3.75km further to the west, which discharges an estimated 12 million tonnes of sediment into Poverty Bay annually.

The ODG seabed sampling sites (OSG 1-4) and reference sites (East and West control) for the 2019 survey, are shown in Figure 13 (the Kaiti Reef sampling sites referred to in section 3.1.6.5 above (P1, P6, P7, P16 and P17 are also shown to the north).

Figure 13: Sampling sites at and near the ODG

Benthic samples were analysed for total recoverable heavy metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg), Dry matter (Ash), Total Organic Carbon (TOC) and particle size distribution.

[23] Eastern Port Dredging Project. Disposal Plume Modelling. MetOcean Solutions Ltd: Report P0331-07. Prepared for Eastland Port. 10/04/2018

Metals

Sediment heavy metal concentrations are presented in Table 8 for the ODG. Results are compared with ANZG 2018[24] default guideline values (DGV's) and upper guideline values (GV-high) (ANZG 2018) and the threshold effects level (TEL) values of MacDonald et al. (1996)[25]. The TEL values are those which would be expected more to approximate background conditions (It is noted that ANZECC 2000 has been since updated by ANZG 2018 but there is no change to the ANZECC 2000 Interim Sediment Quality Guidelines numerical values. They remain the same in ANZG 2018).

Table 8: ODG sediment metal concentrations (All values mg/kg dry wt)

	ODG 1	ODG 2	ODG 3	ODG 4	ODG 4 - 1	ODG East Control	ODG West Control	TEL	ANZG DGV	ANZG GV-high
Arsenic	5.3	6.4	5.8	4.6	4.9	6.1	5	7.24	20	70
Cadmium	0.026	0.038	0.026	0.031	0.034	0.02	0.034	0.68	1.5	10
Chromium	11.7	17	13.6	13.8	13.8	13.5	13.3	52.3	80	370
Copper	5.4	13.2	7.9	6.9	7.4	6.4	6.9	18.7	65	270
Lead	5.5	7.3	6.3	5.3	5.7	6.4	5.6	30.2	50	220
Mercury	0.02	0.05	0.03	0.03	0.03	0.02	0.02	0.13	0.15	1
Nickel	16.8	24	23	20	21	21	20	15.9	21	52
Zinc	41	55	45	44	45	43	43	124	200	410

All sediment metals concentrations, except nickel, fell below (that is 'complied with') the relevant guideline values. Nickel exceeded the TEL at all sites including the east and west control sites and was equivalent to or exceeded the ANZG DGV by a small margin at four sites. Nickel concentrations were well below the ANZG GV-high at all sites.

The site with the highest Nickel concentrations (OSG 2) also had the highest organic carbon and mud content. Increased mud content and organic enrichment are typically associated with increased heavy metal concentrations, as the binding capacity of sediments increases with decreasing grain size, and the partitioning of metals to sediments is also increased with increasing organic carbon content (ANZG 2018). As such, this may be a factor explaining the variation in metals concentration between samples and for example, the slightly increased zinc concentrations at OSG 2.

Total Organic Carbon

Recorded sediment TOC concentrations at the ODG are presented in Table 9: OSG sediment TOC concentrations (%)

Table 9: OSG sediment TOC concentrations (%)

	OSG 1	OSG 2	OSG 3	OSG 4	OSG 4 - 1	OSG East Control	OSG West Control
Total Organic Carbon (%)	0.13	0.44	0.12	0.14	0.14	0.13	0.11

[24] ANZG. 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments. Canberra ACT, Australia. Available at https://www.waterquality.gov.au/anz-guidelines.

[25] MacDonald DD, Carr RS, Calder FD, Long ER, Ingersoll CG (1996) Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology 5:253–278.

TOC concentrations at all ODG sites fall within the 'very good' category of Robertson and Stevens (2007) (see Table 3, page 16 of this report) indicating low levels of organic carbon in the sediments. Notwithstanding that OSG 2 had a slightly higher level of TOC compared to the other samples, none of the results indicate undesirable elevations in organic enrichment at the OSG or the control sites.

Particle Size

The particle size distribution of each of the ODG and control sites is presented in Figure 14 below.

All sites, except OSG 2, had very similar particle size distribution profiles. In general, the samples were comprised predominantly of very fine sand, followed by a smaller component of mud and fine sand. OSG 2 had a higher proportion of mud compared to the other sites.

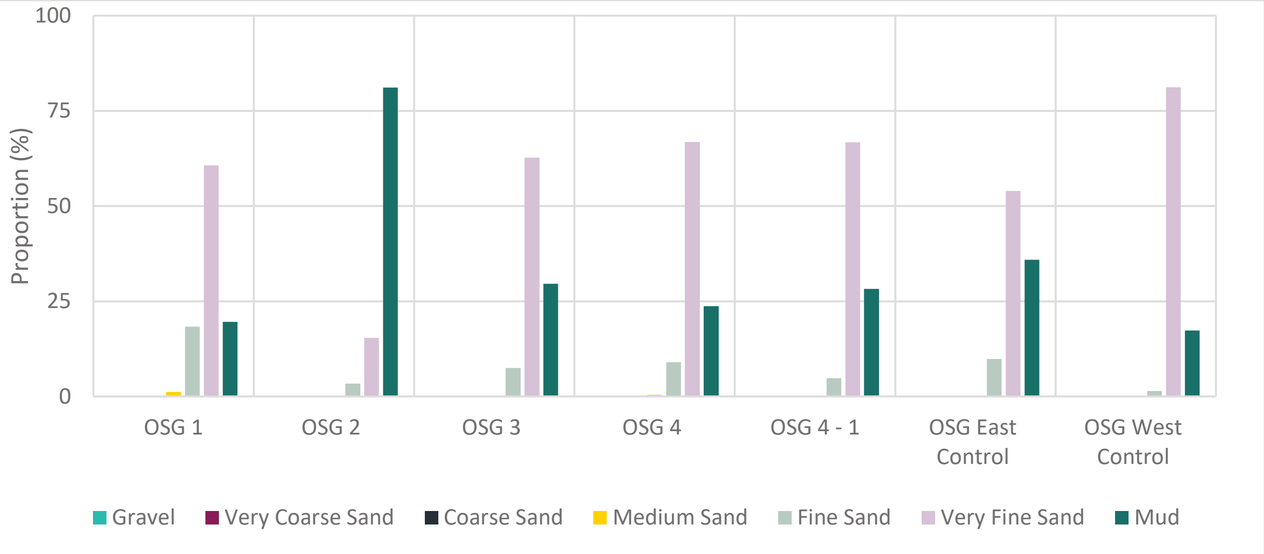

Figure 14: Particle size distribution at the Offshore Disposal Ground

3.5.2 ODG Ecology

Site specific knowledge of the biological characteristics of the seabed at the ODG comes from four studies: two as background surveys prior to any disposal (Cole et al., 1997; Cole et al., 1999[26]); and two as a condition of consent for the existing disposal permit (Halliday et al., 2008[27]; NIWA, 2014).

The most recent of these benthic ecological monitoring reports (NIWA, 2014) reviews the earlier information, and incidental to assessing the effects of the disposal. The 2014 NIWA report provides the following key information about the biological characteristics of the ODG:

- The ODG and adjacent area contained benthic soft sediment communities;
- These communities are represented in the latest study by 79 distinct macrofaunal taxa (32 Polychaeta; 10 Bivalvia; 4 Gastropoda; 10 Amphipoda; 8 Eucarida; 3 Cumacea; 3 Ostracoda;1 Holothurian and 8 other taxa);
- Taxonomic diversity, abundance, evenness and rare species present were not statistically different inside; outside or on the edge of the ODG;

[26] Cole, R., Tindale, D., Richards, L., Glasby, C and Grange, K (1999). *Benthic fauna of the offshore dumping ground in Poverty Bay*. Prepared for Port of Gisborne Ltd. NIWA Client Report PGL 90401, April 1999

[27] Halliday, J., Hailes, S and Hewitt, J (2008). *Effect of dredge disposal on the benthic fauna of the Eastland Port offshore disposal ground, Poverty Bay*. Prepared for Eastland Port Ltd. NIWA Client Report HAM2008-177

- Cole et al (1999) noted that the variability between species in the 1999 and 1997 surveys (pre-disposal) indicated that the existing environment of the ODG area undergoes substantial temporal variation; and
- Communities were comparable to those that were recorded before any disposal occurred, as reflected in the 1997 and 1999 studies.
- The ODG is a high energy location exposed to a large ambient load of river sourced sediment (Edhouse et al., (NIWA), 2014)[28]. NIWA record Cole et al (1997) as concluding that these influences should result in the seabed biota being able to cope with high levels of disturbance.

From these findings, it can be concluded that the benthic communities present in the ODG are consistent with those expected for this location in Poverty Bay and taking into account the physical influences governing the location as identified by Cole et al (1997) and reviewed by Worley Parsons (2015)[29] and more recently discussed in the suite of modelling studies completed by MetOcean (2017, 2019[30]).

3.5.3 ODG Water Quality

Coastal process engineering reviews (Worley Parsons, 2015; MetOcean, December 2017) have confirmed the water quality of the ODG is governed primarily by the physical processes that influence the wider Poverty Bay. The area is strongly influenced by riverine discharges from the Waipaoa River (catchment area 2200 km^2) and the Turanganui River (catchment area 220 km^2). Fluvial load to these rivers is primarily silt and they discharge an estimated 12.1 $x10^6$ and 0.69 x 10^6 tonnes per year respectively of suspended sediment (predominantly fine silt) to Poverty Bay (MetOcean, December 2017; page 27) in discharges that directly influence the ODG. The engineering reports also review the wave and current climate and confirm that the ODG location is high energy and strongly dispersive. Sediment which enters the area, either naturally or by dredging sediment disposal, is for the most part moved offshore into deeper waters and ultimately to the continental shelf.

4 ECOLOGICAL AND WATER QUALITY EFFECTS

This section of the report addresses the following matters:

Port

- Dredging effects on port habitat and biota; and
- Dredging effects on port water quality.
- Biosecurity

Offshore Disposal Ground

- Disposal effects on habitat and biota of the ODG; and
- Disposal effects on water quality of the ODG.

4.1 Dredging Effects on Port Habitat and Biota

4.1.1 East of Butlers Wall-Turning Basin and Berth Pockets

Other than in respect of the investigations undertaken as part of the expansion of the port pre-year 2000, a review of ecological consenting documents for capital and maintenance dredging at the port since that time, indicates there have only been limited biological investigations undertaken of the seabed area affected by dredging. This is assumed

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[28] Edhouse, S., Hailes, S and Carter, K (2014). *Effects of dredge spoil disposal on benthic fauna of the Eastland Port offshore disposal ground*. NIWA Client Report HAM2014-065

[29] Worley Parsons (2015). *Maintenance Dredging and Disposal. Coastal Process Engineering Report. Report 301105-03380-CS- REP-002*. Prepared for Eastland Port, 2 February 2015

[30] Met Oceans Solutions Ltd (November 2019). Eastland Port Dredging Project. Morphological response of the proposed offshore disposal ground. Prepared for Eastland Port, Gisborne.

to be because the area is recognised as a modified commercial port zone within which dredging is a mandatory requirement to maintain gazetted port depths.

The biologically active part of any seabed, even in such a disturbed area, is typically limited to the near surface 20 cm of seabed sediment. The benthic fauna in that zone is described in section 3.1.4 and, due to the ongoing permitted operations of vessels accessing the port and natural water quality variation as described in section 3.3, hosts limited diversity and abundance of benthic macroinvertebrate fauna dominated by common species of polychaete worm.

Because this area is maintained in a near continual state of disruption due to permitted or consented port operations that form part of the existing environment, the direct ecological effects of maintenance dredging on seabed habitat and macrobenthos are not expected to be significant and can be considered minor and probably less than minor. In overview, the biology of the port is not of ecological importance although the potential presence of juvenile crayfish at times attract some interest.

4.1.2 West of Butlers Wall -Port Navigation Channel and Nearby Habitats

Coastal engineering information confirms a high rate of littoral sediment transport from west to east through this area, a proportion of which deposits in and adjacent to the PNC. Thus, maintenance dredging of the PNC will be predominantly unconsolidated silts and sands which occur in a highly mobile and transient environment.

Overall, maintenance dredging effects on this benthic habitat and biota within the PNC are minor due to existing natural processes as well as the same reasons as have been discussed above for the VTB and berth pockets.

Cole et al (1997) reported reef habitats with limited biology near to the PNC. Keeley et al (2002) considered the reefs near to the GDC wastewater outfall, which are close to the PNC, and commented that reef communities on the bottom are subject to low light conditions, high loads of suspended particulates and regular disturbance by storms. Reef communities close to the wastewater outfall were reported as appearing to be particularly suppressed 'by a sandblasting effect from waves and suspended sediment'.

The recent 4Sight surveys of subtidal habitat patch reefs and the intertidal areas of the Kaiti Reef system are consistent with earlier work (eg Coles 1997) and suggest a moderately diverse biota which is evidently robust and capable of withstanding or responding to the high energy conditions which prevail at times. There is no obvious indication of effects from dredging, although any effects would likely be subtle and would be masked by ambient influences. Such effect would likely be inconsequential in terms of the diversity of species to be found and structure of the communities. The ecology of those zones is likely to be governed by substrate type and exposure to wave energy.

Given these applications seek consent for continuation of the same or similar dredging activities as have been undertaken in the past, dredging related influences on those areas are expected to be very limited, if any, and can be considered as minor and probably less than minor.

4.2 Dredging Effects on Port Water Quality

4.2.1 Turning Basin and Berth Pockets East of Butlers Wall

The potential for impact on water quality is strongly related to the dredging method. As noted earlier in this report, two methods are most likely: trailer suction hopper dredge (TSHD) and barge mounted backhoe.

4.2.1.1 TSHD

An analysis of ecological and water quality effects of dredging has been previously prepared as part of the Eastland maintenance dredging application (Andrew Stewart, 2015)[31]. This report remains relevant as the same dredging methods are proposed. For completeness, relevant sections of that analysis are paraphrased below as applicable.

The mode of operation for the Pukunui (and other trailing suction dredges) is for the draghead to be lowered to the seabed and towed at approximately 1-3 knots. The draghead (in this case by way of jetted water) loosens the seabed

[31] Andrew Stewart (2015). *Eastland Port Ltd. Gisborne Port. Maintenance Dredging and Disposal. Port Navigation Channel, Vessel turning Basin, Wharves 7 & 8. Coastal Permit Application. Ecological and Water Quality Report.* January 2015

material which is pumped from the draghead to the hopper barge as a slurry of about 85% water and 15% solids via the dredge pumps. Sediment in the slurry settles into the base of the hopper, leaving a 'cleaner' layer of water on top. The dredge water is decanted back to the sea while the dredge operates and until the hopper fills with a sufficient volume of solids. Dredging information indicates the Pukunui at capacity holds around 220 m^3 of solids and 260 m^3 of dredge water in its 480 m^3 of capacity[32] .

The dredge suction pump operation is essentially an in/out system. Once the hopper (barge or vessel) is full, the same rate of discharge of dredge water decant occurs as is pumped. It typically takes about 30 minutes to fill the hopper to the point that it starts discharging decant water, then a further 1 to 1.5 hours to fill the hopper with sufficient sediment. The hopper (barge/vessel) then moves to the disposal site at a speed of about 6.5 knots.

By way of example, dredging records for 2013 indicate the Pukunui achieves 1 to 7 loads per day with monthly averages of 3 to 4.5 loads per day notwithstanding significant and at times lengthy periods and entire months of no dredging. Dredging typically occurs during daylight hours, but if necessary (due to unusually high dredging demand), operations can also proceed at night. A typical turnaround time to fill, transport, dump and return is in the order of 3 to 4 hours, but it can be as little as 2 hours.

Using an annual maintenance dredging requirement of 100,000 m^3 with peaks up to 140,000 m^3 (Worley Parsons, 2017; Figure 12) the engineers calculated for the entire Port area, between 500 and 700 dredge loads per year at 200 m^3 solids per load average. Translated into days and assuming an average of 4 loads per day, there is an expected requirement for dredging on 125 to 175 days in a typical year for the entire port.

There is ample evidence from photographs and the modelling carried out by MetOcean, that dredging by this method generates plumes of turbidity within the VTB and inner harbour.

The dredging plume modelling makes the following points:

- Modelled scenarios assume a static situation, that is the dredge not moving (MetOcean, April 2018; page 22). This represents a conservative worse case in terms of plume footprints and sediment concentration.
- For the TSHD Pukunui, overflow release is expected to be diffuse and comparable to a point source release occurring on the sea surface layer (MetOcean, April 2018; page 40).
- It is noted that dispersion footprints associated with fine material may seem significant but based on the modelling, plume edges are often associated with suspended sediment concentrations that are in the order of 1-10 mg/l, which can be smaller than background concentrations due to natural river discharges or other sources such as ship movements (MetOcean, April 2018; page 41; para 2; see also Figure 12 of this EWQR).
- It is also noted that the use of an overflow phase from the TSHD, in addition to continuous dredging, results in the most significant increase of predicted suspended sediment concentration throughout the water column (MetOcean, April 2018; page 41; para 3).
- The MetOcean (April 2018) report (page 41; para 5) notes that the moving dredger will allow some dilution of the suspended sediment plume as it moves. In respect of the Pukunui it notes that this movement will mean the decant will lose its initial downward momentum and limits the formation of a downward plume phase.
- The MetOcean (April 2018) report, Figures 3.23 and 3.25, suggests in respect of the Pukunui, suspended sediment (fine material) plume concentrations in excess of 10 mg/l at the sea surface, mid depth and bottom, should not extend more than about 120 m in any direction from the dredge in the VTB and inner harbour. That modelling prediction would effectively encompass much of the port area. High sediment concentrations in excess of 100 mg/l are restricted to a few tens of metres from the dredge throughout the water column.

In summary, TSHD water quality turbidity impacts can be expected to extend throughout most of the VTB and parts of the inner harbour, during any such operations. As such the SC water quality standard in the Tairāwhiti Plan (d) '*The natural colour and clarity of the water shall not be changed to a conspicuous extent*' is unlikely to be met by TSHD methods but such effects are intermittent and short term. Notably however, natural colour and clarity of the inner harbour is highly variable due to natural events and is already regularly compromised by the more regular impacts of

[32] Eastland Port Ltd (2014). *Eastland Port Ltd Maintenance Dredging Liaison Group Annual Report 2013 to the Gisborne District Council*. Prepared by CW Jamieson Marine Manager Eastland Port Ltd, August 2014

routine and permitted ship movements within the port which render high turbidity as a frequent, if not common background state.

4.2.1.2 Backhoe

Backhoe excavator operating from a barge tends to be used in confined spaces or close to port structures and is the more likely method to be employed in the inner harbour zone and close to berth pockets such as those at Wharf 6 and 7. As a mode of excavation, backhoe (i.e. hydraulic digger) removes material which remains relatively cohesive while it is moved from the seabed to the barge. Typically, and in comparison, to the TSHD operation, relatively little water is conveyed with each excavation and much less than suction dredges for each cubic metre of solid material recovered.

The MetOcean (April 2018) report (Figures 3.47 and 3.48) shows a much smaller footprint of increased sediment wherever this method is used. Also, there are no predicted significant increases, comparable to TSHD options, adjacent or extending into the berth face areas. This provides an alternative low impact option for dredging in any area or at any time where crayfish settlement is of interest. Figure 15 below (see MetOcean, November 2019; Figure 3.27) provides a good illustration of the small footprint and localised water quality impact associated with backhoe dredging at Gisborne Port.

In summary, turbidity effects within or adjacent to the backhoe dredging area are typically localised. A significant visual plume of turbid water is unlikely to be generated and the SC water quality standard (d) should be met, other than within the immediate works area.

Figure 15: Backhoe loading Pukunui at Port Gisborne (Source MetOcean, April 2018; Figure 3.44).

(Yellow arrow is discussed in text below)

4.2.1.3 Dredging Related Water Quality Effects on Juvenile Crayfish and Settlement Habitat

The settlement of juvenile crayfish into the port has been documented to occur mostly beneath the presently cantilevered Wharf 6 and part of Wharf 7 (Jeffs, 2018; page 2) as indicated by the arrow in Figure 15 above. In the past, the juvenile settlement appears to occur preferentially in this area. Artificial substrates (crevice collectors) placed elsewhere in the port have shown limited settlement other than in the Wharf 6 and 7 area (Jeffs, pers comm).

As previously noted, consents granted by GDC, but subject to appeals in the Environment Court, would, if confirmed, result in this area being reclaimed to present a vertical quay wall similar to the balance of the Wharf 7 and Wharf 8 area (part of which is also visible in Figure 15 above). Future crayfish settlement will be into removable artificial habitats which will be incorporated into the new quay wall construction.

The fact that juvenile crayfish are reported at times settle strongly into an area that is frequently affected by sediment plumes and presumably high rates of sediment deposition is itself a paradox. It is likely that post larval crayfish suffer high mortality in such areas. This is consistent with the knowledge that their natural habitat is open coastal and relatively high energy and where high rates of sedimentation are not typical.

The reduced salinity that can occur in the port is also worth noting in relation to juvenile crayfish. The juvenile crayfish settle into the port area which can sustain significantly reduced salinity, as shown for example in Table 6 of this report. Reduced salinity is reported to reduce growth rate in some spiny lobster studies and to increase osmotic stress and increase oxygen requirements which can also be exacerbated by elevated seasonal water temperature[33,34]. One relatively recent study showed that growth in juvenile crayfish of the spiny lobster *Panulirus homarus* was greatest in salinities of 35 ppt and progressively reduced at lower salinities[35]. The specific tolerance of juvenile *Jasus edwardsii* to salinity variations that occur in the port is unknown, but the documented periodic low salinity may indicate another local port-specific pressure resulting in a greater potential for mortality.

These potentials for sediment and salinity related mortality pressures can be seen in the context of the very high rates of natural mortality that are reported in the first year after settlement for crayfish species. Jeffs (2018; page 4) cites studies on related species of spiny rock lobster which estimate in the order of more than 95% mortality even in optimal open coastal environments. This suggests that a small percentage of the juvenile crayfish population in the port at any time, will at some future point enter the wild fishery beyond the port environs. This is relevant when considering what mitigation might be warranted in relation to dredging activities.

Existing maintenance dredging consents held by Eastland contain conditions which impose seasonal and other restrictions on dredging in relation to considerations around juvenile crayfish. Specifically, the existing consent covering maintenance dredging for the Wharf 4, 5 and 6 work berths (CP 2013 105825), requires that dredging is not to take place between April and September ('winter') inclusive without the prior written approval of the Council (Condition 4). A previously issued capital dredging consent contained a similar condition requiring that capital dredging within 50 m of Wharf 7 in the period April to September can occur subject to Council approval (CP2008 103663 00, Condition 10).

The April to September period has a biological basis being the period during which crayfish are most likely to move from their planktonic stage to settle in the port and coastal area in general as puerulus juveniles. The long planktonic life cycle (in the order of 18 months) and the vagaries of environmental influences such as currents acting over the continental shelf, preclude a more specific period being identified. Crayfish can settle over an extended period and peaks in settlement usually occur within that period.

In addressing this issue in relation to capital dredging, an assessment of effects prepared by Insight Resource Management Consultancy (2008)[36] refers to a peer review by NIWA dated July 1998 which was reported to state:

> '*…the impacts of capital dredging in the harbour (increase in water depth and alteration of the seafloor) would not have any significant impact on the rock lobster populations in the harbour*,' and further the staff report states

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[33] McLeese, D.W. (1956). *Effects of Temperature, Salinity and Oxygen on the Survival of the American Lobster*. Journal of the. Fisheries Research Board of Canada. 13, 247–272. doi:10.1139/f56-016

[34] Jury, S., Kinnison, Huntting, M., Howell, W. and Watson, W.H. (1994). *The effects of reduced salinity on lobster (Homarus americanus Milne-Edwards) metabolism: implications for estuarine populations*. Journal of Experimental Marine Biology and Ecology 176, 167–185. doi:10.1016/0022-0981(94)90183-X

[35] Vidya, K and Joseph, S (2012). *Effect of salinity on growth and survival of juvenile Indian spiny lobster Panulirus homarus (Linnaeus).* Indian Journal of Fisheries, 59(1):113-118, 2012

[36] Eastland Port Limited (2008). *Capital Dredging of Harbour Waters and Marine Disposal of Dredge Spoil*. Insight (Gisborne Ltd), December 2008

'NIWA expressed a concern that the dredging in the harbour take place outside the main pueruli settlement period between April and September inclusive [the most critical time is May to July incl] to minimise any deleterious effects on research or on *<u>commercial collections</u>* *of spawning* [sic] *of juvenile crayfish*.' [our emphasis]

We are unaware of commercial collections of juvenile crayfish being undertaken at Gisborne Port. Further we understand from discussions with Professor Jeffs, that there are no current or likely proposals for commercial grow on of juvenile crayfish in land-based aquaculture or 're-seeding' of coastal areas. On this basis collection of juvenile crayfish from the port for commercial purposes seems unlikely and the apparent reasons for the original recommended consent conditions aimed at 'protecting' juvenile crayfish may not still be applicable.

The primary reasons that have recently been advanced for a particular consideration of juvenile crayfish in the port is the potential for the at times seasonally high densities to be easily accessed and /or observed by scientists for research purposes and a body of scientific literature which has used or relied on access to these juvenile crayfish. [37].

Existing consent conditions restricting dredging between April and September are intended to mitigate water quality related effects on crayfish juveniles. The beneficial effect of the dredging restriction (if any) is unknown. It appears to reflect a precautionary and largely perceptual approach taken by Council in the past to limit potential exposure of the newly settled crayfish to sediment at a vulnerable life history stage. This seems a poorly based rational as there is an apparently greater and more frequent influence of other sources of sediment in the port (as illustrated in Figure 12 of this report).

It is evident from the example illustrated in Figure 15, that a backhoe dredger can operate with limited impact and sediment plumes are unlikely much beyond the immediate works zone.

A simple consent condition strategy to mitigate potential effects on crayfish habitat associated with maintenance dredging in the immediate Wharf 6 and 7 berth pocket area (i.e. the area of interest in terms of crayfish settlement habitat), would be to require dredging in the April to September period to be restricted to backhoe and outside of that period allow for other methods including TSHD to be used. This approach is more appropriate and likely to reflect actual practice. It avoids any poorly premised blanket restriction on dredging over a significant part of the year.

The decision to grant the Wharf 6 and 7 Consents, also considered the relevant water quality effects of the maintenance dredging associated with the Wharf 6 and 7 project, as it related to crayfish. The potential for effects is not changed under the present proposal to reconsent the existing maintenance dredging volumes.

4.2.1.4 Effects From Potential Mobilisation of Metals and Elutriate Testing

As has been discussed earlier, the concentrations of heavy metals in the dredged sediments has been documented as low, over a lengthy period of annual sediment monitoring. Further assessment has been undertaken of any risk associated with mobilization of dissolved contaminants during the dredging process. Specifically, as part of the 2017 annual sediment testing, the toxicological risk associated with an increase in dissolved contaminants entering the water column due to dredging was assessed by elutriate testing[38]. Elutriate testing is a standardised laboratory based analytical procedure which agitates a sample of the sediments to be dredged and then measures the concentration of dissolved metals in a filtered sample of the elutriate. This analytical procedure mimics the possible effect of dredging on the water column in terms of contaminant mobilisation.

The elutriate analysis indicated that maintenance dredging may cause a small increase in copper concentration in the water column, but the concentrations of other metals are unaffected. The increase in copper is likely to remain small and indicates that water quality will remain within the ANZECC (2000) 90% species protection threshold for marine waters in a 'slightly to moderately disturbed ecosystem'. This level of marine water protection is routinely applied in similar consent conditions and has specifically been imposed by GDC in relation to previous discharge consents issued by GDC.

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[37] Kelly, S. Section 42A Report - Appendix 5.1 Memo Eastland Port Ltd: Application to redevelop the slipway and Wharves 6 & 7. 18 April 2018

[38] Vicinie, A., Palermo, M and Matko, L (2017). *A Review of the Applicability of Various Elutriate Tests and Refinements on These Methodologies.* Proceedings, WEDA XXXI Technical Conference & TAMU 42 Dredging Seminar

4.2.2 Port Navigation Channel West of Butlers Wall

4.2.2.1 TSHD

TSHD is likely to be used for most of the capital dredging and remain the dominant method for the maintenance dredging in this part of the PNC.

In respect of the Pukunui operations, the MetOcean (November 2018) report indicates small plume fields with increases in suspended sediment concentration above 10 mg/l confined for the most part to the PNC or its immediate vicinity (see MetOcean November 2018) report Figures 3.22 and 3.24). This is well illustrated in the photograph presented in Figure 16.

The MetOcean plots do suggest that the patch reefs and stacks closer to the PNC, and which are identified in Figure 5 of this EWQR, could be influenced by the lower concentration range from the dredging plume fields. However as is evident from the Figure 5 photographs, those discrete ecologies appear to be healthy and not to have been unduly affected by historical and current dredging. It seems likely they will not be adversely affected by the proposed maintenance dredging.

Again, it is clear that the SB water quality standard (d) '*The natural colour and clarity of the water shall not be changed to a conspicuous extent'* cannot be met during dredging. This may need to be accommodated in the consent to allow for dissipation of temporary and intermittent plumes to return to background conditions at which they cease to be 'conspicuous'.

Given the assessed benign quality of the maintenance material dredged, it is also most likely that SB water quality standard (e) '*The water shall not be rendered unsuitable for bathing by the presence of contaminants'* can be met. Moreover, while bathing is a relevant measure for assessment, the likelihood of any recreational bathing in this location is extremely low due to health and safety concerns associated with an operational port.

The MetOcean conclusions of sediment concentration fields appear not to impact the Kaiti Reef system, or at least suggest that any dredging derived plume of residual sediment that does impinge on this area, would be at concentrations in the order of less than 5 mg/l. On this basis, and once again considering the likely benign quality of the material to be dredged in respect of sediment associated potential microbiological pathogens, or bioaccumulative compounds such as metals, or other compounds such phenols which might taint seafood, the SA water quality standard (e) as above, and the additional standard (e) applicable to SA waters '*Aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants'* should be met.

Figure 16: TSHD Pukunui operating within the outer PNC (Source MetOcean (November, 2019); Figure 3.9)

4.2.2.2 Backhoe

As already discussed in relation to the inner harbour area, any water quality effects will be very localised and not significant in water quality terms. Backhoe operations are not undertaken in the PNC.

4.3 Disposal Effects on ODG Habitat and Biota

Based on the most recent biological surveys, changes in benthic community composition since 1996 are reported to have been minimal, and impacts associated with the disposal of dredged material in the past do not appear to be significant (NIWA, 2014).

This NIWA conclusion is consistent with expectations derived from recent physical modelling. The MetOcean, (November 2019) report, investigates and predicts through modelling, the morphological responses of disposal of dredging disposal at the ODG.

Section 3.2 Disposal Ground Dynamics of that report (page 20) comments

'…*Simulations of "La Niña" conditions suggest an overall erosion of the sediment mound and dominant north and northwest inshore deposition of sediment, with maximum sediment accretion of 0.05 m. Sediment transport for "El Niño" simulations are predominantly south and southwest with peak sediment accretion of 0.15 m expected within confined region. Between 68% – 83% of the disposed material associated with maintenance dredging is expected to be eroded and transported. This corresponds to between 50,000 m3 and 100,000 m3 of sediment being advected from the disposal ground over a 1-year period (for "La Niña" and "El Niño" respectively). Most of the eroded material consists of the weakly-consolidated silt in the disposed sediment which is predicted to be winnowed from the disposal ground, diffused through the lower water column, and transported towards the shore or continental shelf by suspended-load transport* …' The report further notes that cohesive mud comprises 66% of the expected dredge material, and very fine and fine sand represent 19% and 15% respectively.

Coastal process information reviewed by Worley Parsons (2015) was also reported to show that for typical winter wave conditions, the ODG is in a location experiencing net offshore sediment transport.

This dredging disposal induced scale of deposition can be viewed against the likely ambient flux caused by episodic events at this site (e.g. riverine discharges during and following large floods; cyclonic weather systems which can produce large waves from an easterly and south-easterly quarter). As noted previously, it is estimated the Waipaoa River discharges some 12 million tonnes of fine sediment into Poverty Bay and the Turanganui River a further 0.7 million tonnes annually. The ODG is within the footprint of these riverine discharges. The seabed sediments at the site are reported as being influenced (resuspended) relatively frequently by wave energy from severe storms and occasionally also subject to the influence of gravity flows of fine mud following major riverine discharges (Worley Parsons, 2015).

The benthic biology is as Coles et al (1997) concluded, likely to be adapted to this scale of natural disturbance against which the proposed disposal volumes are a small percentage in annual terms.

On this basis, potential impacts on the habitat value and benthic ecological communities within and near the ODG, from the predicted future disposal of maintenance dredged material, is likely to be small and of a minor scale. There are unlikely to be any effects on the intertidal and subtidal reefs near to the port, from the disposal of dredgings to the ODG.

4.4 Disposal Effects on ODG Water Quality

The water quality classification at the ODG is SA in the Tairāwhiti Plan. The requirements for SA waters have been described in Table 5. Classification standard (e) states:

> *'Aquatic organisms shall not be rendered unsuitable for human consumption by the presence of contaminants and the water shall not be rendered unsuitable for bathing by the presence of contaminants* ….'

This EWQR has concluded that the material to be dredged is unpolluted and does not contain contaminants which might have a toxicological or bioaccumulative effect, although some contaminants such as some heavy metals are present at low or trace levels but below concentrations that would be of water quality concern or interest. Also, the ODG is well distant from reefs or intertidal areas potentially used for harvest of seafood and is well beyond bathing areas. On this basis, this classification standard (e) will be met.

The water classification requirement of most interest is standard (c), that requiring colour and clarity of the water not to be changed to a conspicuous extent after reasonable mixing. Disposal of each dredged load from a hopper, irrespective of the vessel, inevitably creates a temporary plume of turbidity at the ODG.

The MetOcean (April 2018; section 2.3.3; page 23) report, describes the behaviour of sediment released from a hopper. The literature cited indicates that about 10% of the material is entrained in the water column and 90% rapidly settles to the seabed. The modelled suspended sediment concentration plumes, indicate a relatively constrained plume at the surface and mid depth layers, becoming more dispersed in the bottom layer due to a density current.

Predictions for the Pukunui suggest sediment concentrations will generally fall below 10 mg/l within 50 m of the release at the surface and mid depth layers and within 150 m of the release at the bottom water layers.

It is the near surface turbidity that is most likely to impact the water classification standard (c). The extent of the colour/clarity effect appears to be relatively localised based on the MetOcean modelling.

However, it is inevitable that the SA water quality standard will be breached for a short period over a localised area during disposal of material at the ODG. This has been dealt with in previous consents in a pragmatic way by acknowledging that the ODG is well removed from locations of public view, and localised turbidity is unlikely to be conspicuous. Also, there is an intermittency of discharge due to the load/transport/dump cycle and previous and present consents provide an allowance of 6 hours after each dumping episode for the waters to clear. A 6 hour period is arbitrary and this or any other specified time frame is probably not very relevant at this location.

Overall water quality effects at the ODG from the maintenance dredging are predicted to be minor.

4.5 Biosecurity

Two primary aspects of marine biosecurity are considered below. These are:

- Introduction of hazardous marine organisms on dredging and disposal vessels.
- Risk associated with sediments disturbed during dredging and disposal.

4.5.1 Dredging and Disposal Vessels

The trailer suction hopper dredge that does the majority of the dredging work is the Eastland vessel the 'Pukunui'. This vessel presently undergoes a 5 yearly marine survey but has no routine inspections for fan worm or other species of biosecurity interest. Biosecurity checks of the hull of the vessel could be undertaken as part of the annual port and harbour biosecurity surveys undertaken by GDC, or independently. Eastland have agreed to have this aspect included in a Biosecurity Management Plan (BMP) which is proposed as part of the recommended conditions of this consent application. The continued use of the 'Pukunui' is unlikely to change and in that context there will be no change to any associated biosecurity risk.

Other vessels which periodically come into the port to undertake dredging when sediment infill volumes are higher than can be dealt with by the Pukunui, or for other operational reasons, can come from other parts of NZ and overseas. Dredging vessels on entry to NZ waters must comply with Ministry of Primary Industries (MPI) border controls, standards and guidelines which address and mitigate biosecurity risk associated with ballast water; residual on board sediments and biofouling. Entry of these and other domestic vessels into the Gisborne coastal region from outside areas also falls within the biosecurity jurisdiction of GDC[39]. The proposed BMP will provide a process to confirm certification requirements are met.

4.5.2 Sediments Excavated and Disturbed During Dredging and Disposal

Investigation of the sediments within the dredged footprint of the port and PNC for hazardous marine organisms is currently not required. The last comprehensive assessment of the biota at the ODG was in 2014 and this is to be repeated in April 2020. No hazardous marine organisms were reported in the 2014 survey findings.

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[39] 'National leadership for marine biosecurity is the responsibility of the Ministry of Primary Industries (MPI), with responsibility for regional leadership sitting with regional councils' http://www.environmentguide.org.nz/issues/marine/marine-biosecurity/

The risk of transfer of hazardous marine organisms from the dredged area to the nearby ODG can be assessed by reference to a Lyttleton Port investigation by Cawthron Institute (Sneddon et al, 2016; section 9.4)[40]. That report describes a broadly comparable example in the context of associated biosecurity risk and amplifies some important points which are also relevant to the Eastland maintenance dredging programme.

The Channel Deepening Project (CDP) as the Lyttleton example is known, involves 18 million cubic metres of capital dredging and is therefore a much larger project in terms of the scale of dredging activity. Benthic substrates in the Lyttleton channel extension area and the disposal ground are relatively uniform semi-consolidated muds. The Cawthron report notes:

'…*For any risk to arise as a result of spoil transfer, HMO's* [hazardous marine organisms] *would need to be present in the dredged sediments (including associated water), but not in the disposal area, and not only survive the transfer process but also establish self-sustaining populations in the disposal area. However, such events would only be of biosecurity significance if spoil transfer was the only (or major) pathway by which HMO spread and establishment in the disposal area could occur…*]

The Cawthron report further notes that *Sabella* (fanworm) and two other formally designated species (the sea squirt *Styella clava* and the Asian kelp *Undaria pinnatifida*) has been reported from Lyttleton Port. Of these, only fanworm has been reported at Gisborne port. The Cawthron report notes that fan worm (and *Styella*) are more often prevalent on hard substrates but have the capacity to live in soft sediments, especially where shell material is present. Sediments at Eastland port and the ODG do not have a significant shell proportion. They are predominantly very fine sands and muds. The Cawthron report also notes that while there is a theoretical risk of transfer of fan worm in dredge spoil, '…*Sabella would not be able to reattach* [in fine substrates] *and would be unlikely to survive…*'.

The Cawthron report also makes some useful comments in the context of future risk of fan worm spread following the species potentially becoming established within a dredged area or being present in the water column at the time of dredging. In that context the report commented '… *the close proximity of the disposal ground* [in the Lyttleton case about 2km offshore at its closest point] *minimises the risk in terms of subsequent spoil transfer. Relative to the life history and reproductive characteristics of marine species, the distance from the dredged channel to the spoil grounds is short. Any species accidentally introduced to Lyttleton Port … that has the capacity to spread via natural dispersal processes to the dredged channel will equally be capable of spreading to the spoil grounds*…'. The Cawthron report comments that none of the hazardous marine organisms considered in the report, including *Sabella*, are likely to thrive in disturbed conditions.

Overall, the Cawthron report concludes that for the Lyttleton Port Channel project, biosecurity risks were negligible from the proposed capital dredging.

The latest biosecurity survey at Gisborne suggests that there is an active reproducing 'population' of fanworm. Taking the Lyttleton example, similar factors apply in Gisborne Port that should limit future biosecurity risk associated with the presence of fan worm on hard structures at the port and marina. These are in particular:

- the fine, relatively soft substrates in the dredging footprint at the port and the ODG;
- the very high levels of physical disturbance within that footprint from dredging and in the case of the PNC, also from waves and littoral transport of sands in Poverty Bay and mud from the Turanganui river;
- the modelled dispersive character of the ODG and specifically the offshore transport from the ODG of at least a similar volume of sediment annually from the ODG as is likely to be placed on it in the form of maintenance dredged material; and
- the proximity of the ODG to the dredging area and port which makes it more likely that *Sabella* would disperse naturally from the port/marina to that area.

These factors support a conclusion that any biosecurity risk associated with the maintenance dredging is likely to be small and probably negligible at Eastland. While a BMP is warranted to deal with covered in 4.5.1 above, there is little

[40] Sneddon R, Atalah J, Forrest B, Mackenzie L, Floerl O. 2016. Assessment of impacts to benthic ecology and marine ecological resources from the proposed Lyttelton Harbour Channel Deepening Project. Prepared for Lyttelton Port Co Ltd. Cawthron Report No. 2860a. 190 p. plus appendices

if any justification for further assessment or monitoring of sediments for hazardous marine organisms within the dredging footprint. As has been noted, a comprehensive biological survey of the ODG is already part of the proposed monitoring at 5 yearly intervals. That monitoring should be sensitive to any significant colonisation of the ODG by hazardous marine organisms.

5 PROPOSED MONITORING

5.1 Dredging

It is recommended that the present programme of annual monitoring of heavy metals and total petroleum hydrocarbons at representative sites within the VTB and PNC be continued and expanded to include polycyclic aromatic hydrocarbons and total resin acids at sites which will include background reference or control sites. A draft consent condition has been prepared which details this monitoring.

This monitoring is to reaffirm the quality of the sediments to be maintenance dredged, relative to ANZECC (2000) ISQG Low Values where applicable, and its suitability for offshore disposal. It also seeks to monitor a broader range of parameters which better reflect influences from log yard stormwater discharges; specifically resin acids.

It is also recommended that the current triennial elutriate analysis of sediments to be dredged be continued to verify that concentrations of mobilised metals, and particularly dissolved copper concentration, remains within acceptable limits, and specifically within the ANZECC 90% protection level for marine waters.

5.2 ODG

The ODG is presently monitored at five yearly intervals for biological community metrics. This monitoring was due in 2019 but has not be undertaken at the time of writing (it is noted that NIWA has been engaged to repeat this work which will be undertaken early in 2020).

As part of the recently granted consents for the Wharfside Logyard, a monitoring regime was agreed which will see annual assessment of surficial sediment characteristics (texture and chemistry) at the ODG. The same conditions monitoring requirements are proposed for disposal of maintenance dredgings to the ODG.

6 CONSENT TERM

The risk of ecological and water quality effects of maintenance dredging which are concluded to be minor beyond the immediate footprint of the operating dredge, and which are likely to be insignificant relative to the scale of other effects from existing port activities and natural events, do not warrant further 'baseline' or follow up monitoring. On this basis, the ecological and water quality assessment would support a consent of long-term duration.

The proposed sediment quality testing and elutriate testing for the port sediments and the ecological and sediment quality monitoring at the ODG, with appropriate reporting requirements, provide opportunities for sufficient control and management of dredging and disposal activities under a long term consent.

7 CONCLUSIONS

The following conclusions are drawn with respect to maintenance dredging effects, disposal effects, mitigation and monitoring.

7.1 Maintenance Dredging Effects

<u>Habitat and Biota</u>

i. Earlier ecological surveys (Coles 1997, NIWA 2005), biosecurity surveys by GDC over the period 2006 to 2020, combined with recent 4Sight surveys and monitoring since 2015, in combination with a number of recent physical surveys and modelling assessments, provides an adequate baseline of information and data, from which to establish present day ecological values and sensitivity in the dredging footprint and adjacent zones and from which to assess the proposed maintenance dredging. No additional baseline surveys are warranted.

ii. No important habitat or significant biota is likely to occur within any of the dredging footprint. No 'at risk', 'threatened', or species of conservation significance (as listed on the NZ Threat Classification System[41]), will be affected or occurs within the dredging footprint or ODG.

iii. No marine mammals or birds are known to specifically aggregate within dredging area (or ODG).

iv. Effects on the benthic mud habitat and associated biota within the port east of Butlers Wall, will be of less than minor ecological significance. Effects will be the same or similar in scale to that arising from the existing consented dredging activities.

v. Effects on habitat and biota in the PNC west of Butlers Wall which is also dominated by fine substrate, will also be of less than minor ecological significance. This habitat and ecology are naturally suppressed by physical scour from littoral sand movement, high concentrations of suspended material, significant wave energy and low light and have been modified by past port activities.

Water Quality

vi. The sediments to be dredged are unpolluted and not a significant source of bioaccumulative or otherwise potentially persistent or toxic contaminants that could be mobilised or otherwise be transported at concentrations to affect marine life or water quality within or beyond the port zone. The quality of the dredged material poses no material concerns with respect to potentially toxic or bioaccumulative contaminants.

vii. Water quality related dredging effects include increases in suspended sediment and turbidity plumes. Based on the local experience with dredging at the port, and as supported by the MetOcean modelling studies, such effects will be relatively localised and will be of a similar scale and intensity to those already arising from historical dredging activity.

viii. Shipping movements and storm events frequently increase turbidity within the port and can render dredging related effects on turbidity less intense or conspicuous. The harbour is frequently of low sensitivity to dredging related impacts on colour and visual clarity due to these other and often prevailing background influences.

ix. Modelling from MetOcean suggests that there will not be significant dredging related sediment plumes reaching the Kaiti reef system or local beaches. This is consistent with ecological observations which indicate a relatively diverse intertidal and subtidal biological community in the direction of Kaiti reef notwithstanding historical and current port activity.

x. Turbidity generated from the use of a backhoe dredger, is highly localised and a minor effect in terms of harbour water quality.

xi. Water quality classification standards will be met in respect of dredging other than in relation to effects on colour and visual clarity which may be intermittently exceeded for short periods after any dredging episode. Relative to other influences on colour and visual clarity, dredging effects are minor.

xii. Sediment within the port, taking all potential sources into account, could impact habitat and survival of juvenile crayfish which settle into the Wharf 6 and 7 area. Sediment influences on this area are likely governed by the large plumes generated by ship movements on the adjacent wharfs and by storm discharge events. Sediment generated by dredging is likely to be a lesser and small influence on crayfish habitat relative to that arising from these sources. Effects of dredging on sediment potentially affecting juvenile crayfish habitat, can be appropriately managed by consent conditions limiting dredging methods to backhoe dredger adjacent to Wharf 6 & 7 during the potential peak settlement months.

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[41] D Freeman, K Schnabel, B Marshall, D Gordon S Wing, D Tracey and R Hitchmough. Conservation Status of NZ Marine Invertebrates. Threat Classification Series 9

Biosecurity

xiii. At least one notified hazardous marine organism (Mediterranean fanworm) is reported from the port environs. The most recent biosecurity survey suggests a viable reproducing population of this species somewhere in the port.

xiv. An analysis of factors governing the biosecurity risk associated with fanworm within the context of the proposed dredging, and transport and disposal of dredged material, indicates there is likely to be little if any change to the present biosecurity risk. Any biosecurity risk associated with the dredging is concluded to be small and probably negligible, and in any event able to be managed via the BMP.

7.2 ODG effects

xv. The coastal process and modelling studies provide important information in interpreting biological values and ecological effects at the ODG.

xvi. The studies suggest that even in the absence of disposal of dredgings, the biology on this flat fine sediment area of seabed, would be relatively limited and adapted to high natural inputs of sediment. The physical studies have shown that the ODG is a high energy and highly dispersive environment with a net transport of fine material offshore toward the continental shelf. The recent studies have concluded that there will be minor morphological effects on the predominantly muddy seabed within or near the ODG. There is predicted to be an annual transport of movement offshore which is greater in volume than the annual upper maintenance dredging volume.

xvii. From the estimates supplied in the coastal process reporting, sediment depositing at the ODG from the proposed dredging disposal, will remain a relatively small proportion of the ambient flux experienced at the area in response to natural events and in particular relative to riverine sources from the Waipaoa and Turanganui Rivers.

xviii. Disposal of dredged material to the ODG has been shown in successive benthic ecological surveys to have minor effects on the soft seabed communities which characterise the ODG and general area. These communities are considered likely to be adapted and responsive to, the naturally high sediment regime that prevails in the area. Within this context, it is concluded that effects on benthic ecology will continue to be minor.

xix. Modelling studies suggest disposal related turbid plumes are relatively short lived and localised at the ODG.

xx. The water quality classification SA standards will be met in respect of disposal other than in relation to the temporary short-term effects on colour or visual clarity. Such an impact is concluded to be minor.

xxi. There is no concentration of birds or marine mammals at the ODG that might otherwise be affected by the disposal operation.

Biosecurity

xxii. There is no change to the present biosecurity risk associated with disposal of dredged material to the ODG. That risk is concluded to be small and probably negligible, and in any event able to be managed by the BMP.

7.3 Mitigation of effects

xxiii. No mitigation of perceived potential effects on juvenile crayfish settlement is required given the dominating and regular influence of sediment plumes generated by ship and tug movements and storm events within the port. Risks to crayfish, if any will not change relative to the status quo.

xxiv. Should GDC consider some mitigation is required in respect of crayfish habitat, then this could be achieved by limiting the mode of dredging available for use near to Wharf 6 and 7 to backhoe dredging during the months April to September. No restriction is required outside of that time.

xxv. Existing consented requirements relating to mitigation of visual effects on water clarity in the port and the ODG by way of the 2 hours and 6-hour windows respectively allow for plume dissipation following dredging. These time frames are arbitrary and of limited practical use. In the port basin, plumes generated by TSHD and ship movements rapidly permeate the entire basin, making conspicuous visual change between port and background waters difficult to detect. At the ODG, the distance from any vantage points makes plume boundaries with background conditions indistinct and probably notional at best.

xxvi. Notwithstanding the above limitations, the 2- and 6-hour windows may provide a pragmatic, convenient and non-onerous default position and a mechanism to accommodate the intent of the water classification standard in respect of visual clarity and colour.

7.4 Ecological and Water Quality Monitoring

xxvii. It is recommended that the present programme of annual monitoring of heavy metals and total petroleum hydrocarbons at representative sites within the VTB, and PNC be continued and is extended to include the background sites at the port area and to include polycyclic aromatic hydrocarbons and total resin acids at particular sites as proposed in the applicant's proposed consent conditions. This monitoring is to reaffirm the quality of the sediments to be maintenance dredged, relative to ANZECC (2000) ISQG Low Values and its suitability for offshore disposal and to verify that contaminant increases do not occur at the ODG relative to background conditions.

xxviii. It is recommended that triennial elutriate testing of sediments from the VTB is continued to confirm that mobilisation of heavy metals during dredging does not occur at levels that would cause toxicological risk in the water column.

xxix. It is recommended that the ODG and background sites are monitored at five yearly intervals for biological community metrics as well as annually for surficial sediment characteristics (texture and chemistry).

7.5 Biosecurity

xxx. It is recommended that a Biosecurity Management Plan be prepared to address matters raised in section 4.5.1 of this report.

Appendix A:

Wharf 6 and 7 Photos (2017)

Photo 1: Wharf 6 and stern of the dredge 'Pukunui'

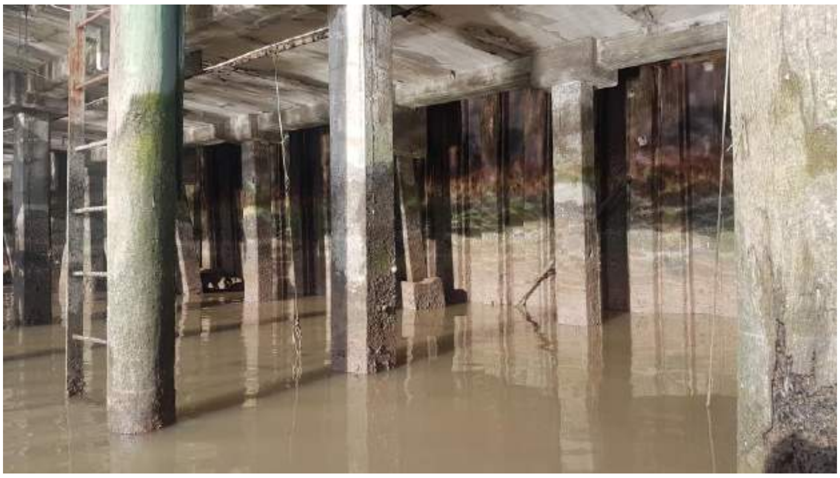

Photo 2: Beneath Wharf 6 looking east

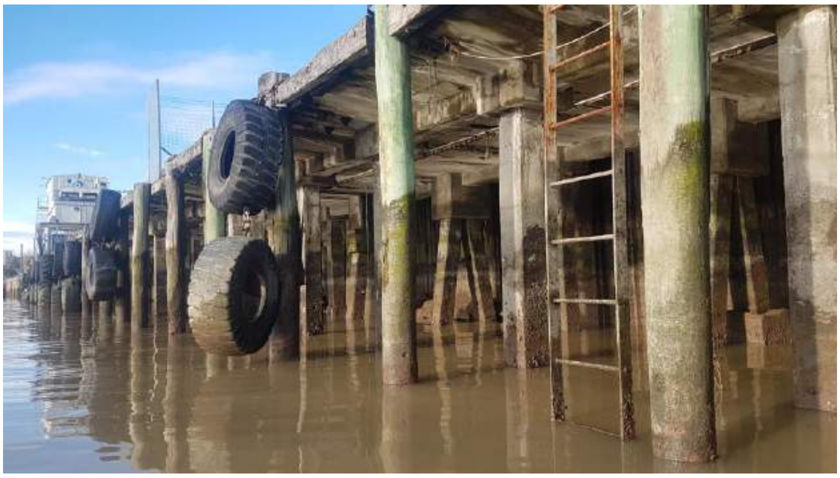

Photo 3: Wharf 6 looking east

Photo 4: Crevice collector retrieved from Wharf 6

Photo 5: Crevice collector side view

Photo 6: Wharf 6 looking east showing a fender (timber) pile, line of front concrete piles and rear raking piles

Photo 7: Crevice collector heavily silted

Photo 8: Wharf 6 old concrete works and rear raking piles

Photo 9: Wharf 6 exposed mudstone bedrock and *Ecklonia* plants

Photo 10: Wharf 6 looking west; exposed bedrock

Photo 11: Wharf 6 looking west, exposed bedrock

Appendix B:

Slipway Photos (2017)

Photo 1: Marine growth on southern steel sheet piles (port side).

Photo 2: Close-up of typical marine growth (Coralline turf algae and *Ecklonia radiata*).

Photo 3: Large cat's eye snails (*Lunella smaragdus*).

Photo 4: Concrete sheet piles showing high concentration of cat's eye snails above turfing algae.

Photo 5: Typical section of northern concrete sheet pile wall adjacent the marine railway.

Photo 6: Typical view of the southern concrete sheet pile wall adjacent the marine railway.

Appendix C:

Biota Recorded from Benthic Samples Adjacent the VTB

Species	Sample A	Sample B	Sample C	Notes
ANNELIDA: POLYCHAETA				
Capitellidae	78	10	11	One species - *Heteromastus filiformis*
Cirratulidae	1			One species
Cossuridae	103	81	118	One species - *Cossura consimilis*
Glyceridae	1	1		One species - *Glycera lamelliformis*
Opheliidae			1	One species - *Armandia maculata*
Sigalionidae		3	3	One species - *Labiosthenolepis laevis*
Spionidae		1		One species - damaged, but likely a *Prionospio* sp.
MOLLUSCA: BIVALVIA				
Semelidae	3	18	18	One species - *Theora lubrica*
ARTHROPODA: CRUSTACEA				
Amphipoda except Phoxocephalidae	2	1	3	Three species - #1 in 'A', #2 in 'B', #2 (2) and #3 (1) in 'C'
Amphipoda Phoxocephalidae	1	1	1	One species
Cumacea Diastylidae		2	1	Probably two species - specimens in 'B' are badly damaged, specimen in 'C' is *Diastylopsis crassior*
Isopoda			1	One species

Appendix D:

GoPro Benthic Habitat Photos (2018)

Concept Reclamation Footpint: Summary of Survey by 4Sight Consulting 28 and 29 March 2018

Video footage using a Go Pro camera at positions in the vicinity of the southern logyard concept reclamation footprints shown in Figure 1.

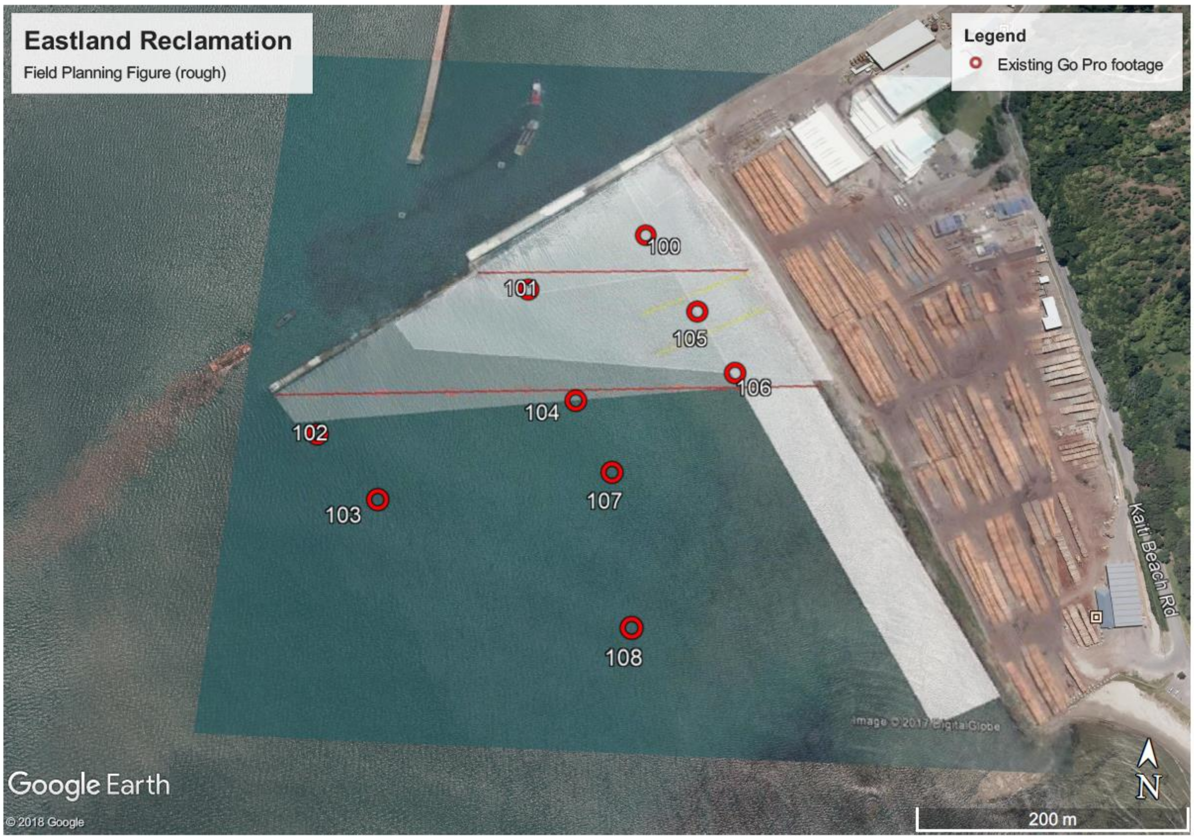

Figure 1: Video sampling positions

Habitats and conspicuous biota seen in the video footage:

Two types of habitat found in the video footage were soft sediment (sand), and rocky reef. Examples of still images captured are shown in Figures 2 and 3. Much of the habitat is soft sandy sediment such as that found at sampling positions 102 and 104 in Figure 1 and seen in Figure 2a. In that habitat, holes and burrows can be seen made by small invertebrates such as polychaete worms and small crustaceans. Patches of brown coloured microalgae are also visible on the sand (Figure 2a). The rocky reef habitat occurs mostly along the inshore margins (e.g. sample position 105 in Figure 1), but also forms patches further from the shoreline (e.g. at sample position 103). The reef habitat supports a diverse community dominated by kelps such as *Ecklonia radiata*, *Carpophyllum* sp. and *Zonaria auriomarginata* (Figure 2b and Figure 3e and f). The diverse understorey and encrusting species on the rocky substrate comprise a range of taxa including coralline algae, sponges and ascidians (Figure 2c). Various fish are associated with the reef habitat including Triplefins (*Forsterygion* sp.)(Figure 2c) and larger reef fishes like sweep (*Scorpis lineolatus*) and koheru (*Decapterus koheru*)(Figure 2d). The breakwater also functions as a reef to support a similar suite of flora and fauna to that on the naturally formed rocky reef habitat (Figure 3f).

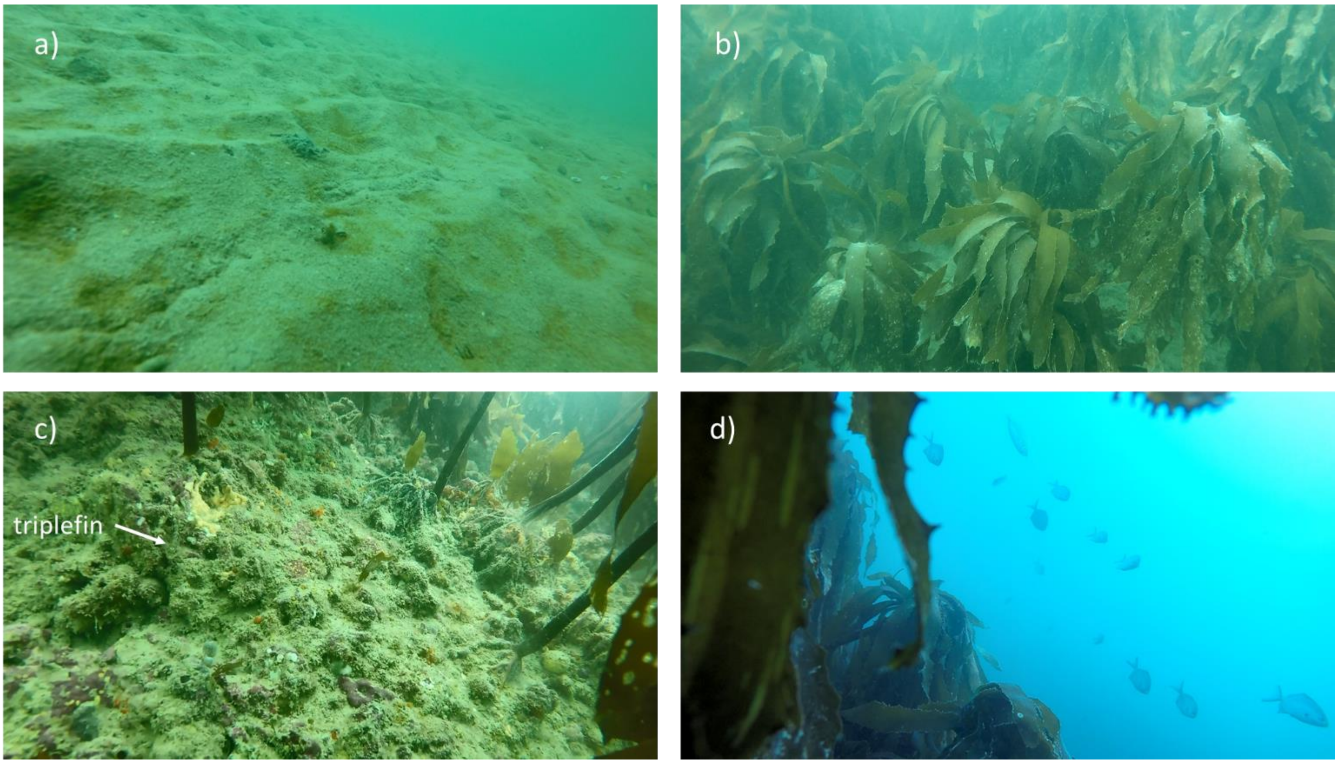

Figure 2: Example still images captured from video footage of the benthos in the vicinity of the proposed reclamation showing a) sandy substrate, b) Kelp (*Ecklonia radiata*) stand, c) diverse understorey biota on reef habitat, d) Reef fishes sweep (*Scorpis lineolatus*) and koheru (*Decapterus koheru*)

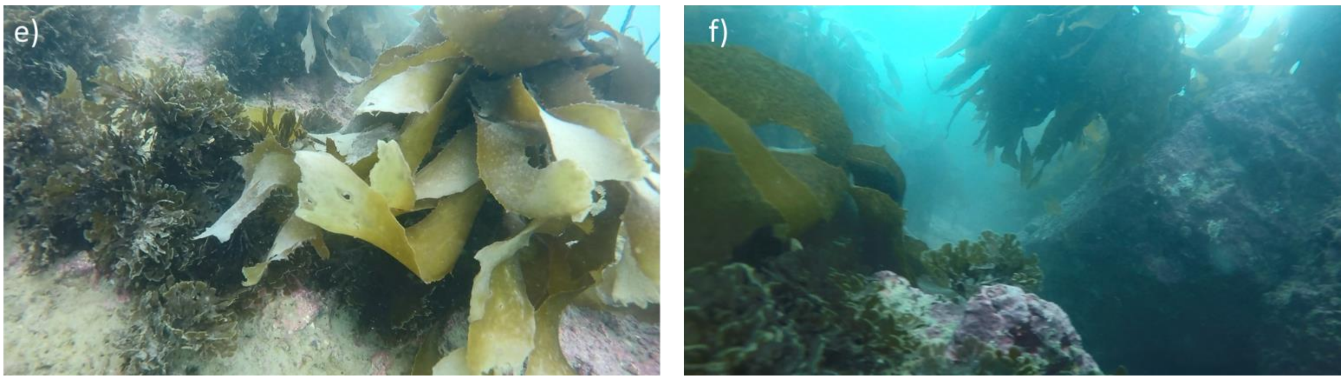

Figure 3: Additional images showing e) kelps (*Zonaria aureomarginata* and *Ecklonia radiata)*, f) rocky habitat and associated biota on the breakwater.

Appendix E:

Kaiti Reef Intertidal (2019)

Survey Information

This survey work has yet to be formally reported. The following is the raw data and record of observations.

On 30 September 2019, 4Sight undertook a survey to document the intertidal species present on Kaiti Beach, Gisborne. Surveying took place along three transects, each running along an onshore - offshore gradient (Fig. 1). The rocky intertidal platform at the Western Kaiti and Eastern Kaiti transects were split into three zones; the high, mid, and low tidal zones. Only a mid tide zone was present at the Outflow transect. In each zone we measured the species present within 10 randomly placed 0.25 m2 quadrats. Care was taken to avoid sampling in obvious cracks, or tide pools. Seaweeds were recorded as percentage cover, and small invertebrates were recorded by counts.

Where we couldn't ID the species accurately in the field, samples were taken for later identification. We also performed a walk through along each transect to record any species that was present, but not sampled in our quadrats.

Fig 1: Location of transects along Kaiti Beach.

The reef at the Eastern Kaiti transect extended further offshore than that at the Western Kaiti or Outflow transects. At Eastern Kaiti, there was an abundance of rock pools present at low tide, and the reef was at a lower elevation that Western Kaiti. At each transect, the high tide zone was dominated by turfing coralline algae and bare rock, the mid tidal zone by Homosira banskii and irregular patches of seagrass, and the low tidal zone, by a variety of seaweeds.

Transect location	Zone	Quadrat	Common name	Scientific name	Percentage cover	Counts per 0.25 m^2 quadrat
Western Kaiti	High tide	1	Olive anemone	*Isactinia olivacea*		14
Western Kaiti	High tide	1	Bare rock		30	
Western Kaiti	High tide	1	Turfing Coralline algae		30	
Western Kaiti	High tide	1	Black encrusting algae		15	
Western Kaiti	High tide	2	Olive anemone	*Isactinia olivacea*		19
Western Kaiti	High tide	2	Bare rock		85	
Western Kaiti	High tide	2	Turfing Coralline algae		5	
Western Kaiti	High tide	2	Black encrusting algae		5	
Western Kaiti	High tide	3	Olive anemone	*Isactinia olivacea*		11
Western Kaiti	High tide	3	Bare rock		25	
Western Kaiti	High tide	3	Turfing Coralline algae		60	
Western Kaiti	High tide	4	Olive anemone	*Isactinia olivacea*		4
Western Kaiti	High tide	4	Turfing Coralline algae		90	
Western Kaiti	High tide	4	Bare rock		10	
Western Kaiti	High tide	5	Olive anemone	*Isactinia olivacea*		5
Western Kaiti	High tide	5	Blue tube worm	*Spirobranchus caraniferus*	< 1	
Western Kaiti	High tide	5	Small black gastropod			1
Western Kaiti	High tide	5	Turfing Coralline algae		80	
Western Kaiti	High tide	5	Bare rock		20	
Western Kaiti	High tide	6	Olive anemone	*Isactinia olivacea*		11
Western Kaiti	High tide	6	Turfing Coralline algae		60	
Western Kaiti	High tide	6	Bare rock		40	
Western Kaiti	High tide	7	Olive anemone	*Isactinia olivacea*		3
Western Kaiti	High tide	7	Turfing Coralline algae		50	

Western Kaiti	High tide	7	Bare rock		50	
Western Kaiti	High tide	8	Olive anemone	*Isactinia olivacea*		9
Western Kaiti	High tide	8	Small crab			1
Western Kaiti	High tide	8	Turfing Coralline algae		55	
Western Kaiti	High tide	8	Bare rock		45	
Western Kaiti	High tide	9	Olive anemone	*Isactinia olivacea*		10
Western Kaiti	High tide	9	White striped anemone	*Anthothoe albocincta*		1
Western Kaiti	High tide	9	Blue tube worm	*Spirobranchus caraniferus*	< 1	
Western Kaiti	High tide	9	Small black gastropod			4
Western Kaiti	High tide	9	Black encrusting algae		< 2	
Western Kaiti	High tide	9	Turfing Coralline algae		70	
Western Kaiti	High tide	9	Bare rock		30	
Western Kaiti	High tide	10	Olive anemone	*Isactinia olivacea*		7
Western Kaiti	High tide	10	White striped anemone	*Anthothoe albocincta*		1
Western Kaiti	High tide	10	Spotted top snail	*Diloma aethiops*		2
Western Kaiti	High tide	10	Small black gastropod			2
Western Kaiti	High tide	10	Turfing Coralline algae		85	
Western Kaiti	High tide	10	Bare rock		15	
Western Kaiti	High tide	10	Blue tube worm	*Spirobranchus caraniferus*	< 1	
Western Kaiti	Mid tide	1	Neptunes Necklace	*Homosira banskii*	45	
Western Kaiti	Mid tide	1	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Mid tide	1	Black encrusting algae		25	
Western Kaiti	Mid tide	1	Thick green algae	*Bryopsis sp.*	< 5	
Western Kaiti	Mid tide	1	Carrageenan weed	*Gigartina clavifera*	< 5	
Western Kaiti	Mid tide	1	Common Pulmonate limpet	*Siphonaria australis*		4
Western Kaiti	Mid tide	2	Neptunes Necklace	*Homosira banskii*	25	

Western Kaiti	Mid tide	2	Turfing Coralline algae		30	
Western Kaiti	Mid tide	2	Bare rock		25	
Western Kaiti	Mid tide	2	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Mid tide	2	Thick green algae	*Bryopsis sp.*	< 5	
Western Kaiti	Mid tide	2	Blue tube worm	*Spirobranchus caraniferus*	< 5	
Western Kaiti	Mid tide	2	Spotted top snail	*Diloma aethiops*		1
Western Kaiti	Mid tide	2	Black encrusting algae		< 5	
Western Kaiti	Mid tide	3	Neptunes Necklace	*Homosira banskii*	80	
Western Kaiti	Mid tide	3	Puff ball algae	*Colpomenia sp.*	< 5	
Western Kaiti	Mid tide	3	Bare rock		< 5	
Western Kaiti	Mid tide	3	Carrageenan weed	*Gigartina clavifera*	< 5	
Western Kaiti	Mid tide	3	Turfing Coralline algae		< 5	
Western Kaiti	Mid tide	3	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Mid tide	3	Soft spongy green		< 5	
Western Kaiti	Mid tide	3	Blue tube worm	*Spirobranchus caraniferus*	< 5	
Western Kaiti	Mid tide	4	Turfing Coralline algae		70	
Western Kaiti	Mid tide	4	Bare rock		30	
Western Kaiti	Mid tide	4	Sea lettuce	*Ulva sp.*	5	
Western Kaiti	Mid tide	4	Puff ball algae	*Colpomenia sp.*	5	
Western Kaiti	Mid tide	4	Carrageenan weed	*Gigartina clavifera*	5	
Western Kaiti	Mid tide	4	Blue tube worm	*Spirobranchus caraniferus*	< 5	
Western Kaiti	Mid tide	5	Seagrass	*Zostera muelleri*	100	
Western Kaiti	Mid tide	6	Blue tube worm	*Spirobranchus caraniferus*	25	
Western Kaiti	Mid tide	6	Bare rock		15	
Western Kaiti	Mid tide	6	Neptunes Necklace	*Homosira banskii*	15	
Western Kaiti	Mid tide	6	Carrageenan weed	*Gigartina clavifera*	20	

Western Kaiti	Mid tide	6	Black encrusting algae		5	
Western Kaiti	Mid tide	6	Sea lettuce	*Ulva sp.*	5	
Western Kaiti	Mid tide	6	Common Pulmonate limpet	*Siphonaria australis*		1
Western Kaiti	Mid tide	6	Ornate limpet	*Cellana ornata*		1
Western Kaiti	Mid tide	7	Bare rock		30	
Western Kaiti	Mid tide	7	Blue tube worm	*Spirobranchus caraniferus*	30	
Western Kaiti	Mid tide	7	Turfing Coralline algae		30	
Western Kaiti	Mid tide	7	Sea lettuce	*Ulva sp.*	5	
Western Kaiti	Mid tide	7	Carrageenan weed	*Gigartina clavifera*	15	
Western Kaiti	Mid tide	7	Black encrusting algae		5	
Western Kaiti	Mid tide	8	Bare rock		70	
Western Kaiti	Mid tide	8	Turfing Coralline algae		40	
Western Kaiti	Mid tide	8	Neptunes Necklace	*Homosira banskii*	10	
Western Kaiti	Mid tide	8	Sea lettuce	*Ulva sp.*	5	
Western Kaiti	Mid tide	8	Puff ball algae	*Colpomenia sp.*	5	
Western Kaiti	Mid tide	8	Carrageenan weed	*Gigartina clavifera*	< 5	
Western Kaiti	Mid tide	8	Blue tube worm	*Spirobranchus caraniferus*	< 5	
Western Kaiti	Mid tide	8	Small black gastropod			1
Western Kaiti	Mid tide	9	Neptunes Necklace	*Homosira banskii*	95	
Western Kaiti	Mid tide	9	Turfing Coralline algae		5	
Western Kaiti	Mid tide	10	Puff ball algae	*Colpomenia sp.*	< 5	
Western Kaiti	Mid tide	10	Neptunes Necklace	*Homosira banskii*	80	
Western Kaiti	Mid tide	10	Turfing Coralline algae		15	
Western Kaiti	Mid tide	10	Carrageenan weed	*Gigartina clavifera*	< 5	
Western Kaiti	Mid tide	10	Black encrusting algae		< 5	
Western Kaiti	Mid tide	10	Turfing Coralline algae		< 5	

Western Kaiti	Mid tide	10	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	1	Feathery red		80	
Western Kaiti	Low tide	1	Puff ball algae	*Colpomenia sp.*	< 5	
Western Kaiti	Low tide	1	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	1	Turfing Coralline algae		80	
Western Kaiti	Low tide	1	Black encrusting algae		5	
Western Kaiti	Low tide	1	Soft spongy green		< 5	
Western Kaiti	Low tide	2	Encrusting velvet weed	*Codium convolutum*	10	
Western Kaiti	Low tide	2	Turfing Coralline algae		95	
Western Kaiti	Low tide	2	Neptunes Necklace	*Homosira banskii*	5	
Western Kaiti	Low tide	2	Carrageenan weed	*Gigartina clavifera*	5	
Western Kaiti	Low tide	2	Puff ball algae	*Colpomenia sp.*	5	
Western Kaiti	Low tide	2	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	3	Encrusting velvet weed	*Codium convolutum*	5	
Western Kaiti	Low tide	3	Carrageenan weed	*Gigartina clavifera*	20	
Western Kaiti	Low tide	3	Feathery red		15	
Western Kaiti	Low tide	3	Turfing Coralline algae		5	
Western Kaiti	Low tide	3	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	3	Bare rock		< 5	
Western Kaiti	Low tide	3	Puff ball algae	*Colpomenia sp.*	< 5	
Western Kaiti	Low tide	3	Spotted top snail	*Diloma aethiops*		2
Western Kaiti	Low tide	4	Encrusting velvet weed	*Codium convolutum*	10	
Western Kaiti	Low tide	4	Turfing Coralline algae		10	
Western Kaiti	Low tide	4	Carrageenan weed	*Gigartina clavifera*	20	
Western Kaiti	Low tide	4	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	4	Feathery red		25	

Western Kaiti	Low tide	4	Black encrusting algae		< 5	
Western Kaiti	Low tide	4	Spotted top snail	*Diloma aethiops*		5
Western Kaiti	Low tide	5	Encrusting velvet weed	*Codium convolutum*	5	
Western Kaiti	Low tide	5	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	5	Neptunes Necklace	*Homosira banskii*	15	
Western Kaiti	Low tide	5	Puff ball algae	*Colpomenia sp.*	< 5	
Western Kaiti	Low tide	5	Turfing Coralline algae		85	
Western Kaiti	Low tide	5	Spotted top snail	*Diloma aethiops*		3
Western Kaiti	Low tide	5	Red-mouthed whelk	*Cominella virgata*		1
Western Kaiti	Low tide	6	Neptunes Necklace	*Homosira banskii*	85	
Western Kaiti	Low tide	6	Turfing Coralline algae		15	
Western Kaiti	Low tide	6	Encrusting velvet weed	*Codium convolutum*	10	
Western Kaiti	Low tide	6	Feathery red		10	
Western Kaiti	Low tide	6	Puff ball algae	*Colpomenia sp.*	< 5	
Western Kaiti	Low tide	7	Bare rock		5	
Western Kaiti	Low tide	7	Neptunes Necklace	*Homosira banskii*	5	
Western Kaiti	Low tide	7	Encrusting velvet weed	*Codium convolutum*	10	
Western Kaiti	Low tide	7	Feathery red		20	
Western Kaiti	Low tide	7	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	7	Turfing Coralline algae		20	
Western Kaiti	Low tide	8	Bare rock		5	
Western Kaiti	Low tide	8	Neptunes Necklace	*Homosira banskii*	5	
Western Kaiti	Low tide	8	Encrusting velvet weed	*Codium convolutum*	15	
Western Kaiti	Low tide	8	Feathery red		30	
Western Kaiti	Low tide	8	Black encrusting algae		5	
Western Kaiti	Low tide	8	Sea lettuce	*Ulva sp.*	< 5	

Western Kaiti	Low tide	8	Spotted top snail			2
Western Kaiti	Low tide	8	Small snail			1
Western Kaiti	Low tide	8	Puff ball algae	*Colpomenia sp.*	< 5	
Western Kaiti	Low tide	9	Feathery red		90	
Western Kaiti	Low tide	9	Red-mouthed whelk	*Cominella virgata*		1
Western Kaiti	Low tide	9	Turfing Coralline algae		< 5	
Western Kaiti	Low tide	9	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	9	Branching velvet weed	*Codium fragile*	< 5	
Western Kaiti	Low tide	9	Spotted top snail	*Diloma aethiops*		1
Western Kaiti	Low tide	10	Encrusting velvet weed	*Codium convolutum*	< 5	
Western Kaiti	Low tide	10	Feathery red		70	
Western Kaiti	Low tide	10	Sea lettuce	*Ulva sp.*	< 5	
Western Kaiti	Low tide	10	Turfing Coralline algae		10	
Western Kaiti	Low tide	10	Red-mouthed whelk	*Cominella virgata*		1
Eastern Kaiti	Low tide	1	Feathery red		15	
Eastern Kaiti	Low tide	1	Furry green		55	
Eastern Kaiti	Low tide	1	Bare rock		10	
Eastern Kaiti	Low tide	1	Black encrusting algae		< 5	
Eastern Kaiti	Low tide	1	Brown seaweed	*Dictyota kunthii*	5	
Eastern Kaiti	Low tide	1	Spotted top snail	*Diloma aethiops*		2
Eastern Kaiti	Low tide	2	Encrusting velvet weed	*Codium convolutum*	5	
Eastern Kaiti	Low tide	2	Branching velvet weed	*Codium fragile*	5	
Eastern Kaiti	Low tide	2	Black encrusting algae		5	
Eastern Kaiti	Low tide	2	Feathery red		5	
Eastern Kaiti	Low tide	2	Turfing Coralline algae		5	
Eastern Kaiti	Low tide	2	Encrusting coralline algae		< 5	

Eastern Kaiti	Low tide	2	Furry green		25	
Eastern Kaiti	Low tide	2	Cat's eye	*Lunella smaragdus*		5
Eastern Kaiti	Low tide	3	Branching velvet weed	*Codium fragile*	< 5	
Eastern Kaiti	Low tide	3	Feathery red		< 5	
Eastern Kaiti	Low tide	3	Furry green		80	
Eastern Kaiti	Low tide	3	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	Low tide	3	Encrusting velvet weed	*Codium convolutum*	5	
Eastern Kaiti	Low tide	3	Encrusting coralline algae		< 5	
Eastern Kaiti	Low tide	3	Brown seaweed	*Dictyota kunthii*	< 5	
Eastern Kaiti	Low tide	3	Spotted top snail	*Diloma aethiops*		1
Eastern Kaiti	Low tide	3	Cat's eye	*Lunella smaragdus*		1
Eastern Kaiti	Low tide	4	Encrusting velvet weed	*Codium convolutum*	10	
Eastern Kaiti	Low tide	4	Furry green		70	
Eastern Kaiti	Low tide	4	Feathery red		15	
Eastern Kaiti	Low tide	4	Branching velvet weed	*Codium fragile*	< 5	
Eastern Kaiti	Low tide	4	Black encrusting algae		< 5	
Eastern Kaiti	Low tide	4	Bare rock		< 5	
Eastern Kaiti	Low tide	4	Cat's eye	*Lunella smaragdus*		3
Eastern Kaiti	Low tide	5	Bare rock			
Eastern Kaiti	Low tide	5	Branching velvet weed	*Codium fragile*		
Eastern Kaiti	Low tide	5	Furry green			
Eastern Kaiti	Low tide	5	Feathery red			
Eastern Kaiti	Low tide	5	Brown seaweed	*Dictyota kunthii*		
Eastern Kaiti	Low tide	5	Oyster boorer	*Haustrum scobina*		1
Eastern Kaiti	Low tide	6	Encrusting velvet weed	*Codium convolutum*	10	
Eastern Kaiti	Low tide	6	Furry green		60	

Eastern Kaiti	Low tide	6	Bare rock		20	
Eastern Kaiti	Low tide	6	Feathery red		15	
Eastern Kaiti	Low tide	6	Branching velvet weed	*Codium fragile*	< 5	
Eastern Kaiti	Low tide	6	Brown seaweed	*Dictyota kunthii*	< 5	
Eastern Kaiti	Low tide	6	Cat's eye	*Lunella smaragdus*		2
Eastern Kaiti	Low tide	7	Encrusting velvet weed	*Codium convolutum*	< 5	
Eastern Kaiti	Low tide	7	Feathery red		50	
Eastern Kaiti	Low tide	7	Furry green		30	
Eastern Kaiti	Low tide	7	Turfing Coralline algae		10	
Eastern Kaiti	Low tide	7	Black encrusting algae		< 5	
Eastern Kaiti	Low tide	7	Cat's eye	*Lunella smaragdus*		1
Eastern Kaiti	Low tide	8	Encrusting velvet weed	*Codium convolutum*	10	
Eastern Kaiti	Low tide	8	Furry green		70	
Eastern Kaiti	Low tide	8	Feathery red		10	
Eastern Kaiti	Low tide	8	Brown seaweed	*Dictyota kunthii*	< 5	
Eastern Kaiti	Low tide	8	Branching velvet weed	*Codium fragile*	< 5	
Eastern Kaiti	Low tide	8	Cat's eye	*Lunella smaragdus*		3
Eastern Kaiti	Low tide	8	Small snail			1
Eastern Kaiti	Low tide	9	Encrusting velvet weed	*Codium convolutum*	15	
Eastern Kaiti	Low tide	9	Furry green		75	
Eastern Kaiti	Low tide	9	Bare rock		< 5	
Eastern Kaiti	Low tide	9	Feathery red		5	
Eastern Kaiti	Low tide	9	Encrusting coralline algae		< 5	
Eastern Kaiti	Low tide	9	Cat's eye	*Lunella smaragdus*		2
Eastern Kaiti	Low tide	9	Small black gastropod			1
Eastern Kaiti	Low tide	10	Turfing Coralline algae		< 5	

Eastern Kaiti	Low tide	10	Encrusting velvet weed	*Codium convolutum*	< 5	
Eastern Kaiti	Low tide	10	Furry green		50	
Eastern Kaiti	Low tide	10	Feathery red		10	
Eastern Kaiti	Low tide	10	Neptunes Necklace	*Homosira banskii*	< 5	
Eastern Kaiti	Low tide	10	Encrusting coralline algae		5	
Eastern Kaiti	Low tide	10	Flat red		15	
Eastern Kaiti	Mid tide	1	Encrusting velvet weed	*Codium convolutum*	10	
Eastern Kaiti	Mid tide	1	Furry green		60	
Eastern Kaiti	Mid tide	1	Neptunes Necklace	*Homosira banskii*	5	
Eastern Kaiti	Mid tide	1	Feathery red		5	
Eastern Kaiti	Mid tide	1	Bare rock		5	
Eastern Kaiti	Mid tide	1	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	Mid tide	2	Zig-zag weed	*Cystophora scaralis*	10	
Eastern Kaiti	Mid tide	2	Furry green		20	
Eastern Kaiti	Mid tide	2	Neptunes Necklace	*Homosira banskii*	15	
Eastern Kaiti	Mid tide	2	Feathery red		5	
Eastern Kaiti	Mid tide	2	Bare rock		< 5	
Eastern Kaiti	Mid tide	2	Puff ball algae	*Colpomenia sp.*	5	
Eastern Kaiti	Mid tide	2	Turfing Coralline algae		5	
Eastern Kaiti	Mid tide	3	Encrusting velvet weed	*Codium convolutum*	< 5	
Eastern Kaiti	Mid tide	3	Black encrusting algae		10	
Eastern Kaiti	Mid tide	3	Turfing Coralline algae		40	
Eastern Kaiti	Mid tide	3	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	Mid tide	3	Zig-zag weed	*Cystophora scaralis*	< 5	
Eastern Kaiti	Mid tide	3	Neptunes Necklace	*Homosira banskii*	< 5	
Eastern Kaiti	Mid tide	4	Bare rock		10	

Eastern Kaiti	Mid tide	4	Black encrusting algae		5	
Eastern Kaiti	Mid tide	4	Furry green		10	
Eastern Kaiti	Mid tide	4	Feathery red		15	
Eastern Kaiti	Mid tide	4	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	Mid tide	4	Sea lettuce	*Ulva sp.*	< 5	
Eastern Kaiti	Mid tide	4	Turfing Coralline algae		25	
Eastern Kaiti	Mid tide	5	Bare rock		20	
Eastern Kaiti	Mid tide	5	Neptunes Necklace	*Homosira banskii*	< 5	
Eastern Kaiti	Mid tide	5	Branching velvet weed	*Codium fragile*	< 5	
Eastern Kaiti	Mid tide	5	Black encrusting algae		20	
Eastern Kaiti	Mid tide	5	Sea lettuce	*Ulva sp.*	< 5	
Eastern Kaiti	Mid tide	5	Turfing Coralline algae		< 5	
Eastern Kaiti	Mid tide	5	Feathery red		5	
Eastern Kaiti	Mid tide	6	Encrusting velvet weed	*Codium convolutum*	5	
Eastern Kaiti	Mid tide	6	Bare rock		< 5	
Eastern Kaiti	Mid tide	6	Neptunes Necklace	*Homosira banskii*	< 5	
Eastern Kaiti	Mid tide	6	Sea lettuce	*Ulva sp.*	< 5	
Eastern Kaiti	Mid tide	6	Furry green		45	
Eastern Kaiti	Mid tide	6	Feathery red		10	
Eastern Kaiti	Mid tide	6	Turfing Coralline algae		20	
Eastern Kaiti	Mid tide	6	Spotted top snail	*Diloma aethiops*		2
Eastern Kaiti	Mid tide	7	Neptunes Necklace	*Homosira banskii*	< 5	
Eastern Kaiti	Mid tide	7	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	Mid tide	7	Bare rock		5	
Eastern Kaiti	Mid tide	7	Furry green		60	
Eastern Kaiti	Mid tide	7	Feathery red		10	

Eastern Kaiti	Mid tide	7	Zig-zag weed	*Cystophora scaralis*	< 5	
Eastern Kaiti	Mid tide	7	Spotted top snail	*Diloma aethiops*		1
Eastern Kaiti	Mid tide	8	Zig-zag weed	*Cystophora scaralis*	15	
Eastern Kaiti	Mid tide	8	Neptunes Necklace	*Homosira banskii*	< 5	
Eastern Kaiti	Mid tide	8	Encrusting velvet weed	*Codium convolutum*	< 5	
Eastern Kaiti	Mid tide	8	Puff ball algae		< 5	
Eastern Kaiti	Mid tide	8	Feathery red		15	
Eastern Kaiti	Mid tide	8	Furry green		5	
Eastern Kaiti	Mid tide	8	Thick green algae	*Bryopsis sp.*	< 5	
Eastern Kaiti	Mid tide	8	Spotted top snail	*Diloma aethiops*		2
Eastern Kaiti	Mid tide	9	Zig-zag weed	*Cystophora scaralis*	5	
Eastern Kaiti	Mid tide	9	Neptunes Necklace	*Homosira banskii*	5	
Eastern Kaiti	Mid tide	9	Furry green		10	
Eastern Kaiti	Mid tide	9	Encrusting velvet weed	*Codium convolutum*	< 5	
Eastern Kaiti	Mid tide	9	Sea lettuce	*Ulva sp.*	< 5	
Eastern Kaiti	Mid tide	9	Turfing Coralline algae		30	
Eastern Kaiti	Mid tide	9	Bare rock		10	
Eastern Kaiti	Mid tide	9	Red-mouthed whelk	*Cominella virgata*		1
Eastern Kaiti	Mid tide	9	Spotted top snail	*Diloma aethiops*		1
Eastern Kaiti	Mid tide	10	Zig-zag weed	*Cystophora scaralis*	10	
Eastern Kaiti	Mid tide	10	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	Mid tide	10	Bare rock		5	
Eastern Kaiti	Mid tide	10	Black encrusting algae		5	
Eastern Kaiti	Mid tide	10	Turfing Coralline algae		40	
Eastern Kaiti	Mid tide	10	Furry green		10	
Eastern Kaiti	Mid tide	10	Feathery red		5	

Eastern Kaiti	Mid tide	10	Red-mouthed whelk	*Cominella virgata*		1
Eastern Kaiti	High tide	1	Puff ball algae	*Colpomenia sp.*	10	
Eastern Kaiti	High tide	1	Turfing Coralline algae		90	
Eastern Kaiti	High tide	1	Bare rock		5	
Eastern Kaiti	High tide	1	Neptunes Necklace	*Homosira banskii*	< 5	
Eastern Kaiti	High tide	1	Feathery red		< 5	
Eastern Kaiti	High tide	1	Furry green		< 5	
Eastern Kaiti	High tide	1	Cat's eye	*Lunella smaragdus*		3
Eastern Kaiti	High tide	2	Neptunes Necklace	*Homosira banskii*	40	
Eastern Kaiti	High tide	2	Bare rock		40	
Eastern Kaiti	High tide	2	Zig-zag weed	*Cystophora scaralis*	< 5	
Eastern Kaiti	High tide	2	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	High tide	2	Furry green		10	
Eastern Kaiti	High tide	2	Feathery red		5	
Eastern Kaiti	High tide	2	Black encrusting algae		< 5	
Eastern Kaiti	High tide	2	Turfing Coralline algae		20	
Eastern Kaiti	High tide	2	Cat's eye	*Lunella smaragdus*		1
Eastern Kaiti	High tide	3	Seagrass	*Zostera muelleri*	100	
Eastern Kaiti	High tide	4	Seagrass	*Zostera muelleri*	10	
Eastern Kaiti	High tide	4	Puff ball algae	*Colpomenia sp.*	5	
Eastern Kaiti	High tide	4	Bare rock		20	
Eastern Kaiti	High tide	4	Feathery red		5	
Eastern Kaiti	High tide	4	Furry green		10	
Eastern Kaiti	High tide	4	Turfing Coralline algae		20	
Eastern Kaiti	High tide	5	Bare rock		15	
Eastern Kaiti	High tide	5	Neptunes Necklace	*Homosira banskii*	15	

Eastern Kaiti	High tide	5	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	High tide	5	Black encrusting algae		< 5	
Eastern Kaiti	High tide	5	Turfing Coralline algae		75	
Eastern Kaiti	High tide	5	Feathery red		< 5	
Eastern Kaiti	High tide	5	Furry green		< 5	
Eastern Kaiti	High tide	6	Bare rock		95	
Eastern Kaiti	High tide	6	Sea lettuce	*Ulva sp.*	< 5	
Eastern Kaiti	High tide	6	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	High tide	6	Furry green		< 5	
Eastern Kaiti	High tide	6	Feathery red		< 5	
Eastern Kaiti	High tide	6	Blue tube worm	*Spirobranchus caraniferus*	< 5	
Eastern Kaiti	High tide	7	Blue tube worm	*Spirobranchus caraniferus*	25	
Eastern Kaiti	High tide	7	Neptunes Necklace	*Homosira banskii*	< 5	
Eastern Kaiti	High tide	7	Turfing Coralline algae		10	
Eastern Kaiti	High tide	7	Puff ball algae	*Colpomenia sp.*	< 5	
Eastern Kaiti	High tide	7	Furry green		5	
Eastern Kaiti	High tide	7	Feathery red		< 5	
Eastern Kaiti	High tide	7	Bare rock		30	
Eastern Kaiti	High tide	8	Puff ball algae	*Colpomenia sp.*	15	
Eastern Kaiti	High tide	8	Neptunes Necklace	*Homosira banskii*	15	
Eastern Kaiti	High tide	8	Turfing Coralline algae		65	
Eastern Kaiti	High tide	8	Blue tube worm	*Spirobranchus caraniferus*	< 5	
Eastern Kaiti	High tide	8	Furry green		5	
Eastern Kaiti	High tide	8	Feathery red		5	
Eastern Kaiti	High tide	9	Neptunes Necklace	*Homosira banskii*	25	
Eastern Kaiti	High tide	9	Puff ball algae	*Colpomenia sp.*	15	

Eastern Kaiti	High tide	9	Bare rock		10	
Eastern Kaiti	High tide	9	Feathery red		10	
Eastern Kaiti	High tide	9	Furry green		5	
Eastern Kaiti	High tide	9	Turfing Coralline algae		70	
Eastern Kaiti	High tide	9	Sea lettuce	*Ulva sp.*	< 5	
Eastern Kaiti	High tide	9	Black encrusting algae		< 5	
Eastern Kaiti	High tide	10	Neptunes Necklace	*Homosira banskii*	25	
Eastern Kaiti	High tide	10	Bare rock		15	
Eastern Kaiti	High tide	10	Puff ball algae	*Colpomenia sp.*	15	
Eastern Kaiti	High tide	10	Turfing Coralline algae		70	
Eastern Kaiti	High tide	10	Blue tube worm	*Spirobranchus caraniferus*	< 5	
Eastern Kaiti	High tide	10	Furry green		5	
Eastern Kaiti	High tide	10	Feathery red		5	
Outflow	Mid tide	1	Feathery red		< 5	
Outflow	Mid tide	1	Furry green		25	
Outflow	Mid tide	1	Puff ball algae	*Colpomenia sp.*	< 5	
Outflow	Mid tide	1	Turfing Coralline algae		65	
Outflow	Mid tide	1	Bare rock		5	
Outflow	Mid tide	2	Turfing Coralline algae		55	
Outflow	Mid tide	2	Furry green		15	
Outflow	Mid tide	2	Feathery red		15	
Outflow	Mid tide	2	Bare rock		10	
Outflow	Mid tide	2	Puff ball algae	*Colpomenia sp.*	< 5	
Outflow	Mid tide	3	Puff ball algae	*Colpomenia sp.*	25	
Outflow	Mid tide	3	Turfing Coralline algae		45	
Outflow	Mid tide	3	Furry green		20	

Outflow	Mid tide	3	Feathery red		15	
Outflow	Mid tide	3	Bare rock		10	
Outflow	Mid tide	4	Bare rock		15	
Outflow	Mid tide	4	Furry green		20	
Outflow	Mid tide	4	Feathery red		15	
Outflow	Mid tide	4	Turfing Coralline algae		5	
Outflow	Mid tide	5	Bare rock		10	
Outflow	Mid tide	5	Feathery red		25	
Outflow	Mid tide	5	Furry green		10	
Outflow	Mid tide	5	Sea lettuce	*Ulva sp.*	< 5	
Outflow	Mid tide	5	Thick green algae		10	
Outflow	Mid tide	5	Turfing Coralline algae		< 5	
Outflow	Mid tide	6	Neptunes Necklace	*Homosira banskii*	20	
Outflow	Mid tide	6	Bare rock		15	
Outflow	Mid tide	6	Black encrusting algae		< 5	
Outflow	Mid tide	6	Sea lettuce	*Ulva sp.*	< 5	
Outflow	Mid tide	6	Feathery red		10	
Outflow	Mid tide	6	Furry green		15	
Outflow	Mid tide	6	Turfing Coralline algae		30	
Outflow	Mid tide	7	Encrusting velvet weed	*Codium convolutum*	< 5	
Outflow	Mid tide	7	Bare rock		< 5	
Outflow	Mid tide	7	Sea lettuce	*Ulva sp.*	< 5	
Outflow	Mid tide	7	Neptunes Necklace	*Homosira banskii*	< 5	
Outflow	Mid tide	7	Furry green		10	
Outflow	Mid tide	7	Feathery red		20	
Outflow	Mid tide	7	Turfing Coralline algae		30	

Outflow	Mid tide	7	Spotted top snail	*Diloma aethiops*		1
Outflow	Mid tide	8	Encrusting velvet weed	*Codium convolutum*	10	
Outflow	Mid tide	8	Bare rock		20	
Outflow	Mid tide	8	Furry green		15	
Outflow	Mid tide	8	Feathery red		20	
Outflow	Mid tide	8	Puff ball algae	*Colpomenia sp.*	< 5	
Outflow	Mid tide	8	Turfing Coralline algae		20	
Outflow	Mid tide	8	Neptunes Necklace	*Homosira banskii*	< 5	
Outflow	Mid tide	9	Bare rock		< 5	
Outflow	Mid tide	9	Furry green		20	
Outflow	Mid tide	9	Feathery red		10	
Outflow	Mid tide	9	Turfing Coralline algae		25	
Outflow	Mid tide	9	Sea lettuce	*Ulva sp.*	< 5	
Outflow	Mid tide	9	Puff ball algae	*Colpomenia sp.*	< 5	
Outflow	Mid tide	9	Black encrusting algae		< 5	
Outflow	Mid tide	10	Bare rock		15	
Outflow	Mid tide	10	Feathery red		10	
Outflow	Mid tide	10	Encrusting velvet weed	*Codium convolutum*	< 5	
Outflow	Mid tide	10	Furry green		60	
Outflow	Mid tide	10	Puff ball algae	*Colpomenia sp.*	< 5	
Outflow	Mid tide	10	Sea lettuce	*Ulva sp.*	< 5	
Outflow	Mid tide	10	Neptunes Necklace	*Homosira banskii*	< 5	
Outflow	Mid tide	10	Turfing Coralline algae		15	
Outflow	Mid tide	10	Cat's eye	*Lunella smaragdus*		1

Appendix F:

Subtidal Kaiti Reef And Offshore Disposal Ground Sediment Quality Report (2019)

4SIGHT CONSULTING

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Eastland Port

OUTER SPOIL GROUND & KAITI REEF SEDIMENT QUALITY ASSESSMENT

For Eastland Port Ltd

November 2019

REPORT INFORMATION AND QUALITY CONTROL

Prepared for:	Eastland Port Limited

Author:	Oliver Bone Ecology Consultant	
Reviewer:	Mark Poynter Principal Ecologist	
Approved for Release:	Michael Lindgreen Director	

Document Name	AA2679_OUTER SPOIL GROUND & KAITI REEF SEDIMENT QUALITY ASSESSMENT_2019.11.26_V1.0

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	V1.0	26 November 2019

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1 INTRODUCTION

This report presents and discusses the results of sampling of marine sediments undertaken in August 2019, for a target range of chemistry, quality indicators and grain size.

The sampling was undertaken at two locations of interest. One area is to the immediate south of Eastland Port seaward of the Kaiti reef system (within 1.5km of the port entrance). This location lies within the potential plume field of discharges from maintenance dredging operations at the port as well as from stormwater discharges from the Eastland Port southern logyard.

The second location is the approved Outer Spoil Ground (OSG) for the Eastland port maintenance dredging. This area lies some 4km to the west of the port in between 18m to 20m water depth. The OSG receives on the order of 100,000 m^3 per annum of port dredgings[1] resulting from the maintenance of gazetted depths within the port. The OSG is also influenced by the Waipaoa River, about 3.75km further to the west, which discharges an estimated 15 million cubic metres of sediment into Poverty Bay annually.

This seabed sampling has not been undertaken specifically in relation to any current resource consent requirement, although it anticipates monitoring required under the Eastland Port Wharfside Logyard and more generally maintenance and capital dredging consents. Eastland Port has commissioned the work to assist with the accumulation of environmental baseline and background information that may generally assist in assessing the effects of port operations.

[1] Eastern Port Dredging Project. Disposal Plume Modelling. MetOcean Solutions Ltd: Report P0331-07. Prepared for Eastland Port. 10/04/2018

2 SAMPLING AND ANALYSIS

Marine sediment sampling was completed over the period 27th – 30th August 2019. Samples were collected using a PONAR grab (8.2 L) deployed from the Eastland Port pilot vessel 'Turanganui'. Two areas of marine seabed were surveyed; the Outer Spoil Ground (OSG); and the seabed directly offshore from and to the south of the Eastland Port Southern Logyard and seaward of the Kaiti Reef (hereafter 'Kaiti Reef').

The sampling sites are shown in Figure 1.

Figure 1: Plan of sampling sites for the Outer Spoil Ground (OSG) and Kaiti Reef

2.1 Outer Spoil Ground (OSG)

To characterise sediment quality within the OSG, four potential 'impact' sites were sampled. These were, one site randomly selected within each quarter of the OSG and two 'control' sites, approximately 500 m from the west and east boundaries of the OSG. While these control sites are well outside the OSG boundary, some sediment may be dispersed at least this far away from the OSG and have some impact on sediment characteristics at these 'control' sites (Halliday et al. 2008)[2]. The sites are labelled OSG 1, OSG 2, OSG 3, OSG 4, OSG West Control and OSG East Control.

A composite of five samples was also taken along a transect (labelled OSG 4-1) to further characterise the sediments at this location in order to investigate what appeared to be slightly finer grained sediments in this area of the OSG.

Due to the limited volume of sediment available in each grab, all samples (except OSG 2) were taken from multiple grabs from the same location. The contents of each grab were transferred to secure containers supplied by Hill Laboratories and stored chilled aboard the vessel. Samples were then stored chilled at 4°C for a maximum of six days before being dispatched by courier to Hill Laboratories for analysis. Chain of Custody documentation is included as Appendix A.

[2] Halliday J, Hailes S, Hewitt J (2008) Effect of dredge disposal on the benthic fauna of the Eastland Port offshore disposal ground, Poverty Bay.

Samples were analysed for total recoverable heavy metals (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg), Dry matter (Ash), Total Organic Carbon (TOC) and particle size distribution.

2.2 Kaiti Reef & Foul Ground

To characterise sediment quality off the Kaiti Reef, sediment samples were collected from five sites (P1, P6, P7, P16 and P17) (Figure 1). The survey off Kaiti Reef initially included 27 sites arranged in a grid pattern within the area of interest (Figure 2).

Figure 2: Seabed sediment sampling sites adjacent to the Kaiti Reef

Samples were only able to be collected from sites P1, P6, P7, P16 and P17. Samples were not able to be collected from the other sites due to the substrate characteristics (e.g. it was either rock or a hard, compacted sand that the PONAR grab could not effectively sample).

Similarly, no samples were able to be collected from the seabed at Foul 1-3 due to the coarseness of the substrate.

For sites P20, P21, P23 and P24, samples were able to be taken, but these were not subject to further physicochemical analysis. However, a brief assessment was made of the general sediment characteristics. A typical seabed sediment sample is shown in Figure 3.

Figure 3: Typical PONAR grab seabed sample

3 RESULTS AND DISCUSSION

Results for the sediment testing are presented below. Full analytical results are presented in Appendix B.

3.1 Heavy Metals

3.1.1 OSG

Sediment heavy metal concentrations are presented in Table 1 for the OSG. Results are compared with ANZG 20183 default guideline values (DGV's) and upper guideline values (GV-high) (ANZG 2018) and the threshold effects level (TEL) values of MacDonald et al. (1996)[4].

Table 1: OSG sediment metal concentrations (All values mg/kg dry wt)

	OSG 1	OSG 2	OSG 3	OSG 4	OSG 4 - 1	OSG East Control	OSG West Control	TEL	ANZG DGV	ANZG GV-high
Arsenic	5.3	6.4	5.8	4.6	4.9	6.1	5	7.24	20	70
Cadmium	0.026	0.038	0.026	0.031	0.034	0.02	0.034	0.68	1.5	10
Chromium	11.7	17	13.6	13.8	13.8	13.5	13.3	52.3	80	370

[3] ANZG. 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments. Canberra ACT, Australia. Available at https://www.waterquality.gov.au/anz-guidelines.

[4] MacDonald DD, Carr RS, Calder FD, Long ER, Ingersoll CG (1996) Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology 5:253–278.

Copper	5.4	13.2	7.9	6.9	7.4	6.4	6.9	18.7	65	270
Lead	5.5	7.3	6.3	5.3	5.7	6.4	5.6	30.2	50	220
Mercury	0.02	0.05	0.03	0.03	0.03	0.02	0.02	0.13	0.15	1
Nickel	16.8	24	23	20	21	21	20	15.9	21	52
Zinc	41	55	45	44	45	43	43	124	200	410

At the OSG, all sediment metals concentrations, except nickel, fell below (that is 'complied with') the relevant guideline values. Nickel exceeded the TEL at all sites and was equivalent to or exceeded the ANZG DGV by a small margin at four sites. Nickel concentrations were well below the ANZG GV-high at all sites.

The site with the highest Nickel concentrations (OSG 2) also had the highest organic carbon and mud content (see section 3.2.1 and 3.2.2 below). Increased mud content and organic enrichment are typically associated with increased heavy metal concentrations, as the binding capacity of sediments increases with decreasing grain size, and the partitioning of metals to sediments is also increased with increasing organic carbon content (ANZG 2018). As such, this may be a factor explaining the variation in metals concentration between samples and for example, the slightly increased zinc concentrations at OSG 2.

3.1.2 Kaiti Reef

At the Kaiti Reef sites, all sediment metals concentrations, except arsenic at P17, were low and fell below the relevant guideline values. The Arsenic value at P17 was approximately double the TEL, but well below the ANZG DGV and GV-high. The slightly higher level of arsenic recorded at P17 may be related to the higher levels of organic enrichment recorded at this site (see section 02.2 below).

Table 2: Sediment metal concentrations adjacent to the Kaiti Reef (All values mg/kg dry wt)

	P1	P6	P7	P16	P17	TEL	ANZG DGV	ANZG GV-high
Arsenic	5.9	4.9	4.5	6.3	14.1	7.24	20	70
Cadmium	0.018	0.017	0.029	0.025	< 0.02	0.68	1.5	10
Chromium	4.7	4.2	4.4	4.9	3.5	52.3	80	370
Copper	3	2.6	2.7	3.6	2.6	18.7	65	270
Lead	2.9	2.3	2.3	3.3	3.3	30.2	50	220
Mercury	< 0.02	< 0.02	< 0.02	< 0.02	< 0.04	0.13	0.15	1
Nickel	5.1	4.7	5	5.6	3.5	15.9	21	52
Zinc	28	22	27	26	15.5	124	200	410

3.1.3 Comparison of OSG and Kaiti Reef Sediment Metal Concentrations

The most important point is that at both sites the concentrations of most heavy metals is very low and at or below what is expected for typical background conditions (i.e. the TEL values).

Only in respect of Nickel at the OSG, and Arsenic at the Kaiti Reef were any results recorded above the TEL thresholds. Nonetheless, Nickel concentrations still show low levels that sit at or marginally above the ANZG DGV, and which would still be regarded as a low value and representative of unpolluted sediments suitable for offshore disposal. Given that the range in values for Nickel within the OSG sit at, or very close to, that for the background sites, it is likely that the Nickel concentrations reflect natural catchment derived influences.

The concentrations of some metals were generally higher at the OSG compared to the levels recorded at the Kaiti

Reef sites. However, the relative elevations in some metals at the OSG is consistent with the different sediment composition at the OSG (i.e. finer grained and higher organic content). This is expected given the geographical separation of the sites, the different hydrodynamic regimes, and the likely influence from the Waipaoa River at the OSG.

Total Organic Carbon

Determination of Total Organic Carbon (TOC) is an important part of environmental characterisation of sediments. TOC in marine sediments has multiple potential sources, although most marine organic carbon comes from photosynthetic fixation of CO_2 by phytoplankton. Other sources potentially important at the OSG include organic matter transported in river discharges and in the port derived sediments, which are known to have an elevated organic composition associated with logyard runoff. Through the direct effect on redox potential (the measurement of the tendency of an environment to oxidize or reduce substrates) of sediments, TOC can have a major influence on chemical and biological processes occurring in sediment, including regulation of the behaviour (and toxicity) of metals and other contaminants.

There are no nationally accepted guideline values for TOC in marine sediments. Instead, values are compared to the classification system of Robertson and Stevens (2007)[5] that was developed for estuarine systems (Table 3).

Table 3: Classification of sediment enrichment according to Robertson and Stevens (2007)

	Very Good	Good	Fair	Poor
TOC percentage	0-1%	1-2%	2-5%	>5%

3.1.4 OSG

Recorded sediment TOC concentrations at the Outer Spoil Ground are presented in Table 4.

Table 4: OSG sediment TOC concentrations (%)

	OSG 1	OSG 2	OSG 3	OSG 4	OSG 4 - 1	OSG East Control	OSG West Control
Total Organic Carbon (%)	0.13	0.44	0.12	0.14	0.14	0.13	0.11

TOC concentrations at all OSG sites fall within the 'very good' category of Robertson and Stevens (2007) indicating low levels of organic carbon in the sediments. Notwithstanding that OSG 2 had a slightly higher level of TOC compared to the other samples, none of the results indicate undesirable elevations in organic enrichment at the OSG or the control sites.

3.1.5 Kaiti Reef

Recorded sediment TOC concentrations at the sites adjacent to the Kaiti Reef are presented in Table 5.

[5]Robertson B, Stevens L (2007) Waikawa Estuary 2007. Fine Scale Monitoring & Historical Sediment Coring.

Table 5: Kaiti Reef sediment TOC concentrations (%)

	P1	P6	P7	P16	P17
Total Organic Carbon (%)	0.06	< 0.13	0.07	0.09	0.25

TOC concentrations at all the Kaiti Reef sites, also fall within the 'very good' category of Robertson and Stevens (2007). TOC concentrations were generally lower than the levels recorded at the OSG sites. One site (P17) had a slightly higher level of TOC than the other sites but this remained well within the 'very good range'.

3.2 Particle Size

The particle size distribution for the samples is presented below.

3.2.1 OSG

The particle size distribution of each of the OSG sites is presented in Figure 4.

All sites, except OSG 2, had very similar particle size distribution profiles. In general, the samples were comprised predominantly of very fine sand, followed by a smaller component of mud and fine sand. OSG 2 had a much higher proportion of mud compared to the other sites.

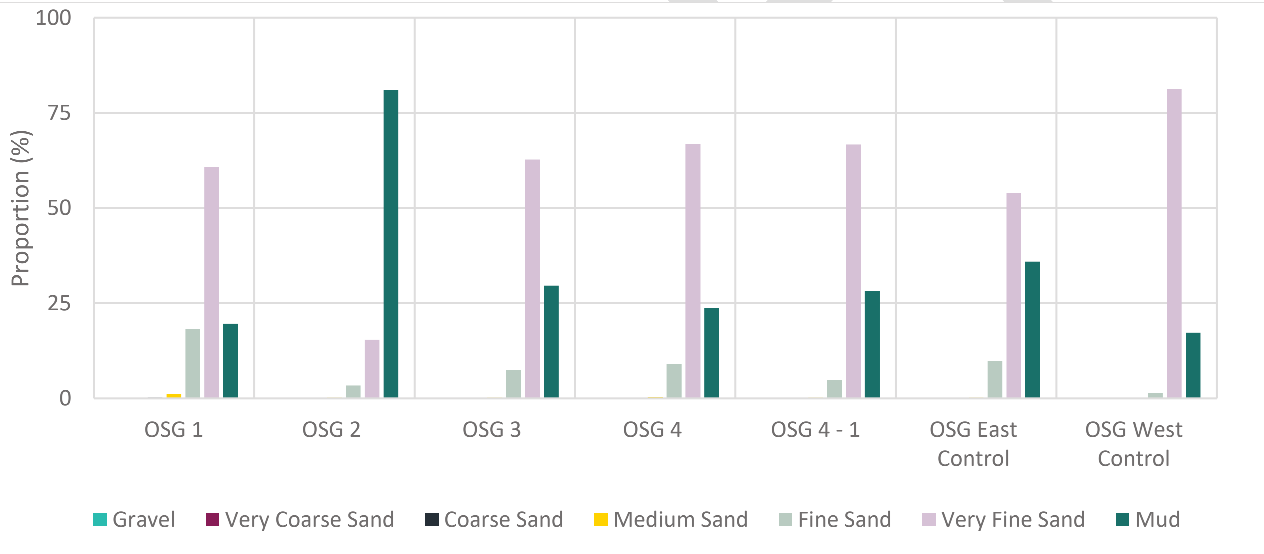

Figure 4: Particle size distribution at the Outer Spoil Ground

3.2.2 Kaiti Reef

The particle size distribution of each of the Kaiti Reef sites is presented in Figure 5 below.

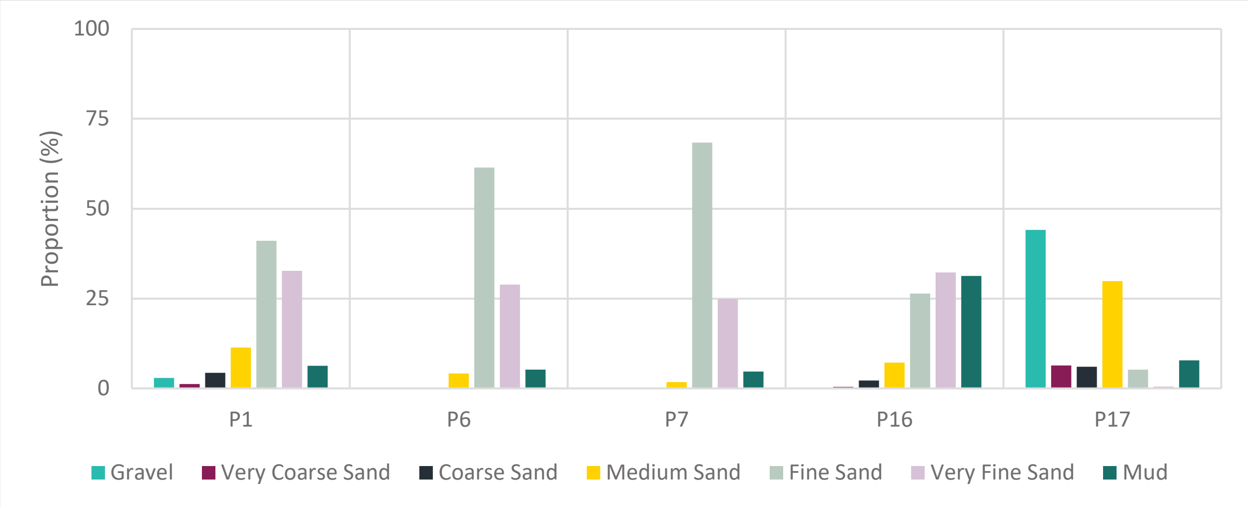

Figure 5: Kaiti Reef particle size distribution

The samples P1 – P16 were comprised predominantly of fine sand and very fine sand, followed by varying levels of mud and medium sand. Coarse sand, very coarse sand and gravel were minor components of these samples. The particle size distribution of P17 was notably different compared to the other samples, being comprised predominantly of gravel and medium sand.

4 CONCLUSIONS

- Overall, sediment quality at all sites was high and had low heavy metal concentrations and organic enrichment. Particle size distribution was also similar between sites within the OSG and the control sites.
- Assuming the control sites are representative of background conditions, the lack of notable differences in sediment quality between the sites within the OSG and the control sites suggests that disposal of dredge spoil at the OSG is not causing a degradation of sediment quality within the OSG.
- The comparative elevation of nickel at both the OSG and control sites suggests the source of nickel may be independent of dredge spoil disposal at the OSG. Further investigation would be required to confirm the source of nickel within Poverty Bay.
- Heavy metal concentrations at the Kaiti reef sites were all low and below TEL guideline values, except arsenic at P17, which was above TEL but below the ANZG DGV. The reason behind this slight elevation is unknown. Due to the very small magnitude it is of no concern at this point.
- Mud content and total organic carbon were similar at all OSG sites, except OSG 2. Mud content and total organic carbon were elevated at OSG 2 relative to the other OSG sites. This suggests that there is some patchiness in the sediment characteristics within the OSG. This patchiness is likely a result of the dredge spoil disposal regime, sediment discharge from the Waipaoa river and other local hydrodynamic influences (e.g. currents, tides and swell).
- There were notable differences in the particle size distribution between the sites at Kaiti Reef. As for the OSG, this patchiness is likely the result of the dynamic interplay between sediment inputs and hydrodynamic influences.

Appendix A:

Chain of Custody Forms

Hill Laboratories
TRIED, TESTED AND TRUSTED

ANALYSIS REQUEST

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Job No: **223 4459** Date Recv: 03-Sep-19 05:56
Received by: Zandra Edwards
3122344595

Quote No 100216

Primary Contact Oliver Bone 245579
Submitted By Oliver Bone 245579
Client Name 4SIGHT Consulting Limited 219138
Address PO Box 402053, Tutukaka 0153

Phone 093030311 *Mobile* 027 601 6620
Email oliverb@4sight.co.nz
Charge To 4SIGHT Consulting Limited 95478
Client Reference AA3018 - Reclamation Ecology
Order No AA3018

Results To *Reports will be emailed to Primary Contact by default. Additional Reports will be sent as specified below.*

- [x] Email Primary Contact
- [ ] Email Submitter
- [ ] Email Client
- [ ] Email Other
- [ ] Other

CHAIN OF CUSTODY RECORD

Sent to Hill Laboratories
- [x] *Tick if you require COC to be emailed back*

Date & Time: 02-09-19
Name: Oliver Bone
Signature: OB

Received at Hill Laboratories
Date & Time:
Name:
Signature:

Condition
- [ ] Room Temp
- [x] Chilled
- [ ] Frozen

Temp: 8.0

- [ ] Sample & Analysis details checked

Signature:

ADDITIONAL INFORMATION

12
13
14
15

Priority
- [ ] Low
- [ ] Normal
- [x] High
- [ ] **Urgent** (ASAP, extra charge applies, please contact lab first)

NOTE: The estimated turnaround time for the types and number of samples and analyses specified on this quote is by 4:30 pm, 7 working days following the day of receipt of the samples at the laboratory.

Requested Reporting Date:

Quoted Sample Types

Sediment (Sed)

No.	Sample Name	Sample Date/Time	Sample Type	Tests Required
1	OSDG 1	28-29/08/19	Marine Sediment	Total Organic Carbon, HM Suite (trace), grain size gravimetric
2	OSDG 2	↓	↓	
3	OSDG 3			↓
4	OSDG4			(for all 12 samples)
5	OSDG4-1			
6	OSDG East Control			
7	OSDG West Control			
8	Port 1			
9	Port 7			
10	Port 6			
11	Port 16			
12	Port 17	↓	↓	↓

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Job Information Summary

Client:	4SIGHT Consulting Limited	**Lab No:**	2234459
Contact:	Oliver Bone	**Date Registered:**	03-Sep-2019 9:13 am
	C/- 4SIGHT Consulting Limited	**Priority:**	High
	PO Box 402053	**Quote No:**	100216
	Tutukaka 0153	**Order No:**	AA3018
		Client Reference:	AA3018 - Reclamation Ecology
		Add. Client Ref:	
		Submitted By:	Oliver Bone
		Charge To:	4SIGHT Consulting Limited
		Target Date:	15-Oct-2019 4:30 pm

Samples

No	Sample Name	Sample Type	Containers	Tests Requested
1	OSDG 1 28-Aug-2019	Sediment	PSoil500	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
2	OSDG 2 28-Aug-2019	Sediment	cPSoil500, cPSoil	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
3	OSDG 3 28-Aug-2019	Sediment	PSoil500	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
4	OSDG 4 28-Aug-2019	Sediment	PSoil500	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
5	OSDG 4 - 1 28-Aug-2019	Sediment	PSoil500	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
6	OSDG East Control 28-Aug-2019	Sediment	PSoil500	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
7	OSDG West Control 28-Aug-2019	Sediment	PSoil500	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
8	Port 1 28-Aug-2019	Sediment	cPSoil	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
9	Port 6 28-Aug-2019	Sediment	cPSoil	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
10	Port 7 28-Aug-2019	Sediment	PSoil500	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
11	Port 16 28-Aug-2019	Sediment	cPSoil	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon
12	Port 17 28-Aug-2019	Sediment	cPSoil	Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg; 7 Grain Sizes Profile as received; Ash; Total Organic Carbon

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Individual Tests			
Environmental Solids Sample Drying	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-12

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-12
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-12
Ash	Ignition in muffle furnace 550°C, 6hr, gravimetric. APHA 2540 G 23rd ed. 2017.	0.04 g/100g dry wt	1-12
Total Organic Carbon	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-12
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.4 mg/kg dry wt	1-12
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-12
Fraction >/= 2 mm	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-12
Fraction < 2 mm, >/= 1 mm	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 1 mm, >/= 500 µm	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 500 µm, >/= 250 µm	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 250 µm, >/= 125 µm	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 125 µm, >/= 63 µm	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 63 µm	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12

Appendix B:

Hill Laboratory Analysis Report

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Certificate of Analysis

Client:	4SIGHT Consulting Limited	**Lab No:**	2234459 SUPv1
Contact:	Oliver Bone	**Date Received:**	03-Sep-2019
	C/- 4SIGHT Consulting Limited	**Date Reported:**	24-Sep-2019
	PO Box 402053	**Quote No:**	100216
	Tutukaka 0153	**Order No:**	AA3018
		Client Reference:	AA3018 - Reclamation Ecology
		Submitted By:	Oliver Bone

Sample Type: Sediment

Sample Name:		OSDG 1 28-Aug-2019	OSDG 2 28-Aug-2019	OSDG 3 28-Aug-2019	OSDG 4 28-Aug-2019
Lab Number:		2234459.1	2234459.2	2234459.3	2234459.4
Individual Tests					
Ash*	g/100g dry wt	98.1 ± 1.5	95.4 ± 1.4	98.0 ± 1.5	98.0 ± 1.5
Total Organic Carbon*	g/100g dry wt	0.134 ± 0.042	0.445 ± 0.054	0.125 ± 0.042	0.142 ± 0.042
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg					
Total Recoverable Arsenic	mg/kg dry wt	5.28 ± 0.55	6.38 ± 0.66	5.83 ± 0.60	4.59 ± 0.48
Total Recoverable Cadmium	mg/kg dry wt	0.0262 ± 0.0068	0.0375 ± 0.0076	0.0256 ± 0.0068	0.0306 ± 0.0071
Total Recoverable Chromium	mg/kg dry wt	11.7 ± 1.5	17.0 ± 2.1	13.6 ± 1.7	13.8 ± 1.7
Total Recoverable Copper	mg/kg dry wt	5.45 ± 0.78	13.2 ± 1.9	7.9 ± 1.2	6.93 ± 0.98
Total Recoverable Lead	mg/kg dry wt	5.48 ± 0.66	7.27 ± 0.88	6.33 ± 0.77	5.35 ± 0.65
Total Recoverable Mercury	mg/kg dry wt	0.0245 ± 0.0072	0.0501 ± 0.0090	0.0292 ± 0.0075	0.0256 ± 0.0073
Total Recoverable Nickel	mg/kg dry wt	16.8 ± 1.7	23.6 ± 2.4	22.6 ± 2.3	20.2 ± 2.1
Total Recoverable Zinc	mg/kg dry wt	40.7 ± 6.6	55.4 ± 8.9	44.6 ± 7.2	43.7 ± 7.0
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample*	g/100g as rcvd	79	61	78	80
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	< 0.1	< 0.1	< 0.1
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	< 0.1	< 0.1	< 0.1	< 0.1
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.2	< 0.1	< 0.1	0.1
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	1.2	0.2	0.2	0.4
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	18.3	3.4	7.5	9.0
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	60.7	15.4	62.7	66.8
Fraction < 63 µm*	g/100g dry wt	19.6	81.1	29.6	23.7

Sample Name:		OSDG 4 - 1 28-Aug-2019	OSDG East Control 28-Aug-2019	OSDG West Control 28-Aug-2019	Port 1 28-Aug-2019
Lab Number:		2234459.5	2234459.6	2234459.7	2234459.8
Individual Tests					
Ash*	g/100g dry wt	97.9 ± 1.5	97.9 ± 1.5	98.0 ± 1.5	98.2 ± 1.5
Total Organic Carbon*	g/100g dry wt	0.136 ± 0.042	0.130 ± 0.042	0.112 ± 0.041	0.063 ± 0.041
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg					
Total Recoverable Arsenic	mg/kg dry wt	4.90 ± 0.51	6.11 ± 0.63	4.99 ± 0.52	5.89 ± 0.61
Total Recoverable Cadmium	mg/kg dry wt	0.0340 ± 0.0073	0.0199 ± 0.0065	0.0336 ± 0.0073	0.0176 ± 0.0064
Total Recoverable Chromium	mg/kg dry wt	13.8 ± 1.7	13.5 ± 1.7	13.3 ± 1.6	4.68 ± 0.58
Total Recoverable Copper	mg/kg dry wt	7.4 ± 1.1	6.44 ± 0.92	6.90 ± 0.98	3.03 ± 0.45
Total Recoverable Lead	mg/kg dry wt	5.67 ± 0.69	6.37 ± 0.77	5.58 ± 0.67	2.89 ± 0.35
Total Recoverable Mercury	mg/kg dry wt	0.0255 ± 0.0073	0.0225 ± 0.0071	0.0201 ± 0.0070	< 0.02 ± 0.0070
Total Recoverable Nickel	mg/kg dry wt	21.1 ± 2.2	21.3 ± 2.2	20.0 ± 2.0	5.08 ± 0.53
Total Recoverable Zinc	mg/kg dry wt	44.9 ± 7.2	42.6 ± 6.9	42.9 ± 6.9	28.2 ± 4.6

The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked *, which are not accredited.

Sample Type: Sediment					
Sample Name:		OSDG 4 - 1 28-Aug-2019	OSDG East Control 28-Aug-2019	OSDG West Control 28-Aug-2019	Port 1 28-Aug-2019
Lab Number:		2234459.5	2234459.6	2234459.7	2234459.8
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample*	g/100g as rcvd	79	79	78	80
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	< 0.1	< 0.1	2.9
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	< 0.1	< 0.1	< 0.1	1.2
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	< 0.1	< 0.1	< 0.1	4.3
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	0.2	0.2	< 0.1	11.4
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	4.8	9.8	1.4	41.1
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	66.7	54.0	81.2	32.7
Fraction < 63 µm*	g/100g dry wt	28.2	35.9	17.3	6.3

Sample Name:		Port 6 28-Aug-2019	Port 7 28-Aug-2019	Port 16 28-Aug-2019	Port 17 28-Aug-2019
Lab Number:		2234459.9	2234459.10	2234459.11	2234459.12
Individual Tests					
Ash*	g/100g dry wt	98.4 ± 1.5	98.3 ± 1.5	97.8 ± 1.5	97.1 ± 1.5
Total Organic Carbon*	g/100g dry wt	< 0.13 ± 0.042	0.067 ± 0.041	0.090 ± 0.041	0.253 ± 0.045
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg					
Total Recoverable Arsenic	mg/kg dry wt	4.85 ± 0.51	4.46 ± 0.47	6.35 ± 0.65	14.1 ± 1.5
Total Recoverable Cadmium	mg/kg dry wt	0.0175 ± 0.0064	0.0286 ± 0.0070	0.0252 ± 0.0068	< 0.02 ± 0.0065
Total Recoverable Chromium	mg/kg dry wt	4.21 ± 0.53	4.44 ± 0.55	4.90 ± 0.61	3.48 ± 0.44
Total Recoverable Copper	mg/kg dry wt	2.60 ± 0.39	2.72 ± 0.41	3.61 ± 0.53	2.56 ± 0.39
Total Recoverable Lead	mg/kg dry wt	2.33 ± 0.29	2.30 ± 0.28	3.26 ± 0.40	3.26 ± 0.40
Total Recoverable Mercury	mg/kg dry wt	< 0.02 ± 0.0070	< 0.02 ± 0.0070	< 0.02 ± 0.0070	< 0.04 ± 0.0081
Total Recoverable Nickel	mg/kg dry wt	4.67 ± 0.49	4.95 ± 0.52	5.55 ± 0.58	3.51 ± 0.38
Total Recoverable Zinc	mg/kg dry wt	22.4 ± 3.7	26.6 ± 4.3	26.0 ± 4.2	15.5 ± 2.6
7 Grain Sizes Profile as received					
Dry Matter of Sieved Sample*	g/100g as rcvd	79	79	78	81
Fraction >/= 2 mm*	g/100g dry wt	< 0.1	< 0.1	0.2	44.1
Fraction < 2 mm, >/= 1 mm*	g/100g dry wt	< 0.1	< 0.1	0.4	6.4
Fraction < 1 mm, >/= 500 µm*	g/100g dry wt	0.2	0.1	2.2	6.0
Fraction < 500 µm, >/= 250 µm*	g/100g dry wt	4.2	1.8	7.2	29.9
Fraction < 250 µm, >/= 125 µm*	g/100g dry wt	61.4	68.4	26.4	5.2
Fraction < 125 µm, >/= 63 µm*	g/100g dry wt	28.9	24.9	32.3	0.5
Fraction < 63 µm*	g/100g dry wt	5.2	4.7	31.3	7.8

The reported uncertainty is an expanded uncertainty with a level of confidence of approximately 95 percent (i.e. two standard deviations, calculated using a coverage factor of 2). Reported uncertainties are calculated from the performance of typical matrices, and do not include variation due to sampling.

For further information on uncertainty of measurement at Hill Laboratories, refer to the technical note on our website: www.hill-laboratories.com/files/Intro_To_UOM.pdf, or contact the laboratory.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Individual Tests			
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-12
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-12
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-12
Ash*	Ignition in muffle furnace 550°C, 6hr, gravimetric. APHA 2540 G 23rd ed. 2017.	0.04 g/100g dry wt	1-12

Sample Type: Sediment			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1-12
Heavy metals, trace As,Cd,Cr,Cu,Ni,Pb,Zn,Hg	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, trace level.	0.010 - 0.4 mg/kg dry wt	1-12
7 Grain Sizes Profile as received			
Dry Matter for Grainsize samples (sieved as received)*	Drying for 16 hours at 103°C, gravimetry (Free water removed before analysis).	0.10 g/100g as rcvd	1-12
Fraction >/= 2 mm*	Wet sieving with dispersant, as received, 2.00 mm sieve, gravimetry.	0.1 g/100g dry wt	1-12
Fraction < 2 mm, >/= 1 mm*	Wet sieving using dispersant, as received, 2.00 mm and 1.00 mm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 1 mm, >/= 500 µm*	Wet sieving using dispersant, as received, 1.00 mm and 500 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 500 µm, >/= 250 µm*	Wet sieving using dispersant, as received, 500 µm and 250 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 250 µm, >/= 125 µm*	Wet sieving using dispersant, as received, 250 µm and 125 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 125 µm, >/= 63 µm*	Wet sieving using dispersant, as received, 125 µm and 63 µm sieves, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12
Fraction < 63 µm*	Wet sieving with dispersant, as received, 63 µm sieve, gravimetry (calculation by difference).	0.1 g/100g dry wt	1-12

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

Ara Heron BSc (Tech)
Client Services Manager - Environmental